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ABSTRACT

This first volume of a two-volume final report describes a project concerned with developing indepth metric teaching units in the areas of carpentry and machine shop, preparing instructional materials to teach metrics in Spanish, and developing three-dimensional metric instructional materials and cassette tapes for persons with reading difficulties and sight handicaps. An introductory section describes procedures used in accomplishing the goals: (1) planning and consultation with specialists in the four areas, (2) development of the instructional material by consultants under the direction of the Director of the Center for Metric Education and Evaluation, and (3) evaluation of the materials developed for persons with reading difficulties and sight handicaps using other consultants with special competencies in evaluation. The remainder of volume I consists of an outline for developing a model of career education and the teaching-learning modules developed in the project for teaching metrics in carpentry (44 pages), in machine shop (28 pages), and in bilingual (Spanish) education (115 pages). (Volume II, bound separately, covers the materials for persons with reading difficulty and the sight handicapped and presents project conclusions.) (LAS)

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FINAL REPORT

Volume I of Two Volumes

Project No. V0151VZ
OE Grant No. OEG-0-74-1661

METRIC CONVERSION IN VOCATIONAL EDUCATION

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May 1976

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U.S. DEPARTMENT OF
HEALTH, EDUCATION, AND WELFARE

Office of Education
Bureau of Occupational and Adult Education

CE 010 115

ABSTRACT

The project Metric Conversion in Vocational Education had four major objectives, namely developing indepth teaching units in the area of carpentry and machine shop, preparing instructional materials to teach metrics in the Spanish language, developing three-dimensional instructional materials and cassette tapes for persons with reading difficulties, and developing three-dimensional materials and cassette tapes for teaching persons with sight handicaps. In each of the four aspects of the project, consultants with special competencies were used in developing and evaluating the instructional materials.

In developing these four aspects of the project, three steps were followed:

1. Planning for each aspect of the project was done in consultation with specialists in each of these four areas.
2. Development of the instructional material was done by consultants under the direction of the Director of the Center for Metric Education.
3. Evaluation of the material developed for persons with reading difficulties and sight handicaps was done using other consultants with special competencies in the area of evaluation.

Complete details including photographs, drawings, and scripts of the cassette tapes are included in this report so that anyone interested in any phase of this project will be able to reproduce the materials.

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Section 1

INTRODUCTION

While Americans reflect on the past two hundred years of this Nation's growth, it is also a good time to remember another revolution that is now occurring; namely, the reform of the customary system of measurement to a new, internationally understood, modernized metric system. This year, 1975, marks the one hundredth anniversary of the beginning of the international acceptance of SI, the modern metric system of weights and measures.

The signing of the Treaty of the Meter by seventeen nations including the United States in Paris, France, on May 20, 1875, was a major step in developing a universally accepted language of measurement. Since that date the world has been slowly but surely converting from the customary system to the metric system. While the United States made the metric system legal in 1866, little was done to implement this change. However, when in the 1960's Great Britain and the other countries that were formerly its colonies began to change from their customary (Imperial) system to the metric system, it became evident that the United States could no longer resist the change.

In February of 1972, proposed legislation to help the United States switch to use of the metric system of measurement from the common inch-pound system was sent to Congress by the then Secretary of Commerce, Peter G. Pierson. This legislation would create a metric conversion board to plan and coordinate a voluntary conversion process in which metric units such as the metre, litre and kilogram would become the most common units of measurement in the United States as they are in all the other industrial nations in the world. This legislation was an outgrowth of recommendations based on a three-year study by the National Bureau of Standards, which was sent to Congress in 1971 in a report entitled, A METRIC AMERICA: A DECISION WHOSE TIME HAS COME.

Since this bill was first sent to Congress, there has been a continuous debate as to whether or not the United States, as the last industrial nation in the world not to have a national policy, should pass metric legislation. During the period 1972 through 1975 more than a dozen different bills were introduced into Congress. Finally, however, on December 23, 1975, President Ford signed the Metric Conversion Act of 1975, which was known in the Senate as S100. In signing the bill the President said that the continued use of the English system of measurement makes the United States an island in a metric sea. He went on to say that in 1965 Great Britain renounced the old system of measurement in favor of the metric system. Since that date all of the other former British colonies have made a formal commitment. Today more than ninety percent of the world's people use the metric measurement system in their everyday life.

The U.S. Metric Conversion Board will be responsible for coordinating the increased use of the metric system in various sections of the economy. The conversion is a completely voluntary one. However, since most Federal boards and agencies will be responsible for metric conversion, the influence will be felt by all sectors of our economy.

The metric system was designed around the following principles advocated by scientists, mathematicians and technologists.

1. The society using a decimal numbering system should have a decimalized measuring system.
2. Units of length, volume and weight should have a direct relationship of one to the other.
3. The value of the basic unit of length should be taken from some unchanging, absolute standard found in the physical universe.

PROBLEMS IN METRIC CONVERSION AND VOCATIONAL EDUCATION

The problem with metric conversion will be far more difficult in vocational education then it will be in the areas of math, science and other academic areas. In the academic fields the student will be concerned primarily with the measuring system called the SI (International System of Units) metric system. This replaces the older metric systems such as the cgs and the MKS that were used up to 1960. However, in vocational education the student must not only learn the measuring system, but he must also learn how to use the measuring system with tools, materials and processes and also understand the international and national standards involved.

It has been estimated that the world will need about eleven thousand new metric standards for materials. Today, only about one hundred fifty are available. However, students must learn about these standards and how to use them. For example, the student in auto mechanics and machine shop must have complete familiarity with the ISO (International Organization for Standardization) standards. Two examples follow.

Threads

The Industrial Fasteners Institute, at the request of the American National Metric Council, began work in 1972 on the development of the Optimum Metric Fastener System (OMFS). This system was an adaptation of the ISO metric threads. This was a single pitch series, which was completely compatible with ISO except for one size, namely M6.3. In 1974 IFI produced the first standard for the Optimum Metric Fastener System. While completely compatible with ISO this system differed in several respects including:

1. the addition of the M6.3 x 1 size
2. a different method of identifying the threads
3. a different method of gaging the threads.

In early 1975 meetings were held in various parts of the world to iron out the differences between the Optimum Metric Fastener System and the existing ISO thread standards. As a result of these meetings, agreement was reached whereby the Optimum Metric Fastener System was incorporated into the ISO metric thread system. As a result of these agreements, a revised ISO standard for threads is in the process of being issued. This revised standard will include the M6.3 x 1 size required by the automotive industries in North America as well as other minor changes in the shape and size of the root of the thread. With this revised ISO standard the United States will use a preferred set of ISO threads, which will be in effect, the Optimum Metric Fastener System.

As a result of these changes, the use of metric threads will require changes in lathes, new thread cutting equipment, wrenches and many other changes. This is only one example of how students in vocational education must have a much more comprehensive understanding of metric change than students in math and science.

Paper Sizes

Students in business and office occupations must also learn about the ISO metric paper standards. All countries going metric are changing paper and envelope sizes to this standard. Slowly but surely there will be metric standards used including lumber, cloth, metals, plastics and thousands of other items.

Despite the great amount of publicity about conversion to the metric system and the use of national and international metric standards, very little has actually been done in the field of education, and particularly in the field of vocational education. This is principally due to the fact that there has been no long-range planning for education and training of teachers in the metric system and ISO standards. However, before any of these things can be done, it is necessary to make careful analyses of occupations to determine what kind and how much metric capabilities each individual and group must know. Also the metric system of measurement will require special training programs for the disadvantaged, handicapped and minorities. It was with these ideas in mind that the proposal for federal assistance was made to the U.S. Office of Education for a project entitled, Metric Conversion in Vocational Education.

OBJECTIVES

This project has four major objectives including:

1. Make an analysis of four career clusters to determine what kinds of competencies are needed in the area of SI metric measuring systems, application of the metric system to tools, materials and processes and use of national and international ISO standards. The four career clusters selected were manufacturing, construction, health, and business and office. On the basis of these analyses a detailed teaching unit is to be developed for two occupations.
2. Prepare simple metric instructional materials in the language of one of the minority groups. It was decided to translate some of the material prepared during an earlier federal project entitled, GOING METRIC FOR CAREER EDUCATION into Spanish and to evaluate these materials.
3. To develop simple metric instructional materials for persons with reading difficulty.
4. To develop three-dimensional and audio materials for teaching metrics to persons with sight handicaps.

HOW THE PROJECT WAS ACCOMPLISHED

Most of the activities of this project were completed by consultants under the direction and in cooperation with the Director of the Center for Metric Education. Consultants included:

1. Task analysis and curriculum experts. Contact was made with the Directors of the projects in each of the four career cluster areas selected. Evaluation of our material was also undertaken by experts in the field. Graduate assistants in Industrial Education developed the metric competence analyses for the four career areas. A special consultant was hired to produce the teaching kit in carpentry.
2. Spanish consultants included the Spanish specialist for the Clark Equipment Company (a company heavily involved in metric conversion) and a graduate assistant in the language department at Western Michigan University whose brother is enrolled in the engineering technology curriculum at Western. Both of these individuals come from a South American country. The chairman of the Spanish Division of the language department at Western Michigan University also served as a consultant.

Evaluation of these materials was completed using the Centers for Bilingual Education throughout the United States. Also vocational instructors involved in teaching Spanish in vocational and technical programs evaluated the material.

3. Learning difficulty specialists for persons with reading difficulties. Consultants for this aspect of the project included the HumRRO Organization (Human Resources Research Organization) and the Center for Evaluation at Western Michigan University.
4. Experts in the blind area included the Chairman of the Blind Rehabilitation Department at Western Michigan University, the individual in charge of blind training at Hines Hospital in Chicago and Miss Elizabeth Lennon of the Blind Rehabilitation Department. In addition, Assistant Professor Isabelle Smith of the Home Economics Department, Western Michigan University, who regularly teaches a course in home economics for the blind, rounded out this team of experts.

PROCEDURES

The procedures followed in developing each of these four aspects of the project were accomplished in three major steps.

1. Planning. In planning each of these aspects of the project consultants were used to help establish guidelines for developing the instructional materials.

2. Development. The actual development of the instructional material was under the direct supervision of the Director of the Center for Metric Education. Extensive use of the various laboratories in Industrial Education was made to build the models and three-dimensional learning aids.

3. Consultants. Persons with a wide variety of talents were needed. For example, in the area of developing instructional materials for the persons with reading difficulty and the blind, a group of specialists including designers, artists, wood and metal technologists were used to actually construct the models and kits of learning materials. In the area of written materials such as the Spanish and curriculum analyses, graduate students in Industrial Education, Language and in Evaluation were utilized.

4. Evaluation. Evaluation of all four aspects of this project was a continuous activity. In the area such as the Spanish metric materials, a variety of teachers and agencies in all parts of the United States used these materials.

In the area of slow learners, these materials were tested with students enrolled in vocational programs at a special technical institute.

In the area of curriculum analysis, the materials were utilized by the federally funded metric project at The Ohio State University.

Section 2

Part A

CURRICULUM STUDIES

DEVELOPING A MODEL FOR CAREER EDUCATION

The U.S. Office of Education has determined that all occupations can be listed under fifteen major career clusters, which include: Agribusiness and Natural Resources, Business and Office, Health, Public Service, Environment, Communications and Media, Hospitality and Recreation, Manufacturing, Marketing and Distribution, Marine Science, Paper Science, Construction, Transportation, Consumer and Homemaking Education and Fine Arts and Humanities. Figure 2A-1.

Some of these career clusters will involve much more SI metric measurement conversion than others. Within each occupation the level and amount of measuring skills will vary considerably. Some types of occupations are concerned primarily with linear and area measurement while others will deal with more complicated concepts as pressure, stress, force, density, velocity, power and luminous intensity.

In converting from our customary system to the SI metric measuring system, all career clusters will need new knowledges and skills. Based on the amount of SI metric measurement conversion involved, it was decided to make a metric task analysis for four of the career clusters; namely health, business and office, construction and manufacturing. As a first step in these analyses, contact was made with the director of each of the federally funded cluster projects in each of these areas. This included Mr. A. Cameron Buchanan, Project Director, Career Education in Manufacturing; Mr. Harry Hoffman, Project Director for career clusters in business and office; Mr. Miles H. Anderson, Project Director for Allied Health Professional Project; and Mr. W. F. Fitz, Program Director, Office of the Deputy Associate Commissioner for Occupational Education and Technology for the construction curriculum project. In each case, all of the materials that were currently available from these projects were obtained.

For example, in the area of career education in manufacturing, complete materials for all areas of manufacturing were obtained. It was found, however, that a very limited amount of these materials included any reference to measuring concepts. Only in the unit on metal manufacturing were there analyses of these concepts, and as might be expected, they were expressed in customary units.

To make a task analysis of the measuring concepts in each of the four career clusters, analysis sheets were developed which included the units in SI--both base and derived, the metric standards currently available from ISO (International Organization for Standardization) and the application of SI metric to tools, equipment and processes. In addition, a description of the level of competency needed for each of these measuring concepts was made. These could be useful in helping curriculum developers determine which content to include in these career clusters at various levels of instruction.

Five representative occupations in each of these four career clusters were selected from the Occupational Outlook Handbook and the Dictionary of Occupational Titles. Based on a review of the curriculum materials available in each of the four career clusters, an analysis of competencies was made in terms of levels of achievement. Samples of this breakdown are shown for each of the four career clusters of manufacturing, business and office occupations, health and construction. See Section 2, Parts B, C, D, and E. These analyses can then be used by curriculum makers or for course revision in the following ways.

1. A review could be made of community colleges and area vocational schools for course offerings in each of the four career clusters to determine the kinds of courses offered in each of these areas.

2. Analyze the most common courses included in each of the career preparation programs.

3. Based on the description of these courses, suggest modifications and additions to include metric competencies needed.

Based on the analysis of the area of manufacturing and construction, it was decided to develop an indepth teaching-learning module for two of the most common vocational areas, carpentry and general machines. These indepth studies were developed using slightly different formats, but as typical curriculum construction programs. Both indepth teaching-learning modules included most of the following:

1. analysis of the learning units in each of the occupations;
2. development of metric competencies needed for the skilled craftsman;
3. performance objectives;
4. learning activities;
5. suggested tools and equipment modification;
6. and instructional materials suitable for both the teacher and learner.

Complete packets for carpentry and machine shop follow in Section 2, Parts F and G respectively.

Figure 2A-1

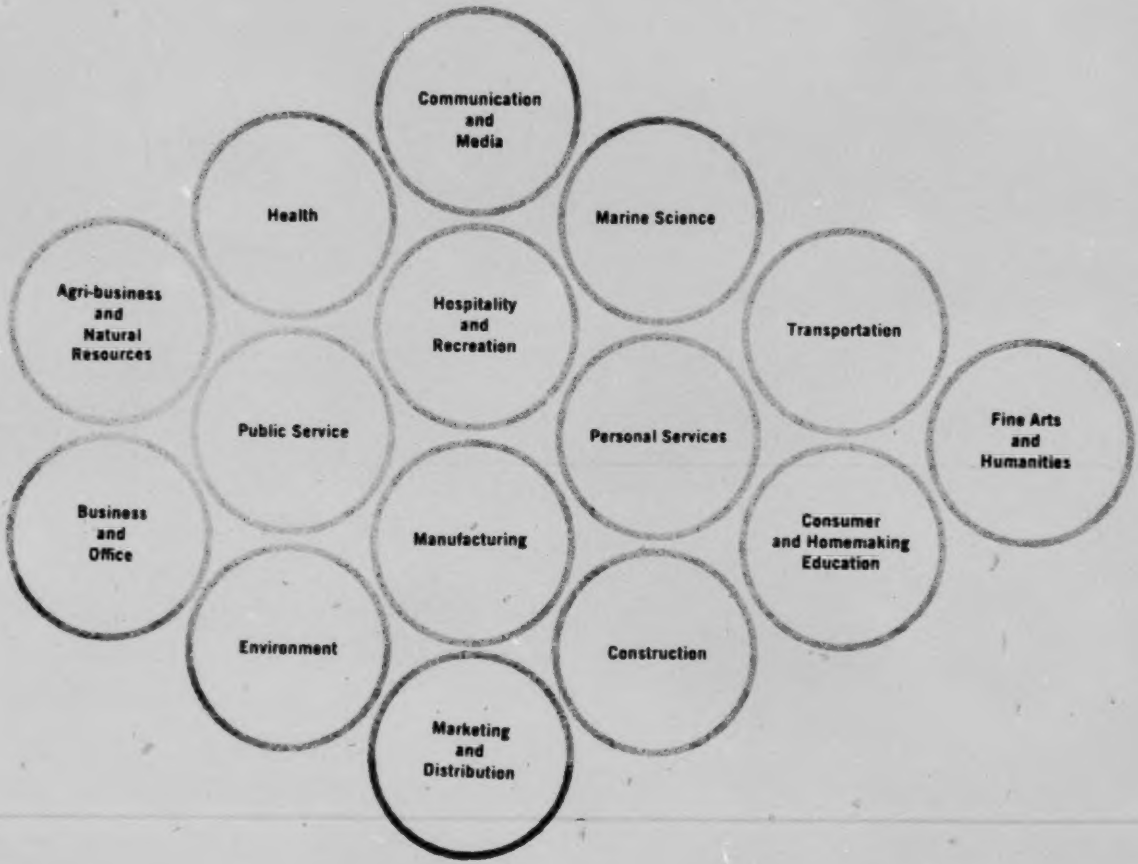
Communication and Media
Health
Marine Science
Agri-business and Natural Resources
Hospitality and Recreation
Transportation
Public Service
Personal Services
Fine Arts and Humanities
Business and Office
Manufacturing
Consumer and Homemaking Education
Environment
Construction
Marketing and Distribution

Figure 2A-2

LEVELS OF COMPETENCY

Level 1. Does not apply. The individual in this occupation does not have to know anything about this aspect of metrics.

Level 2. Basic understanding (awareness). The individual at this level must recognize the name of the unit, know its definition and be able to spell it correctly. He must be able to use the correct symbols. He will generally be aware of its use in the particular occupation. He must know about the metric standards related to that occupation.

Level 3. Vocational application. The individual at this level is assumed to be involved in an occupation at the vocational level. He must know and be able to use metric units, standards and applications of a journeyman in his particular trade.

Level 4. Technical application. The individual in this occupation must be able to know and use metric units, standards and applications at the level of the technician. Since technicians work on terms with engineers, scientists, supervisors and skilled craftsmen converting theories and ideas into products and processes, he must be able to utilize the necessary metric capabilities in these endeavors. Typical occupations in which these competencies will be found are in areas such as construction, technology, mechanical technology, industrial engineering technology, etc.

Section 2
Part B

CAREER CLUSTER - MANUFACTURING

Level of Competency

Level 1: -

Level 2: X

Level 3: 0

Level 4: *

	BASE							DERIVED														
Occupation	Length - metre - m	Mass - kilogram - kg	Temperature - degrees Celsius - °C	Time - second - s	Electric current - ampere - A	Luminous intensity - candela - cd	Amount of substance - mole - mol	Area - m^2	Volume - m^3	Liquid capacity - litre	Force - N	Pressure and stress - Pa	Energy - J	Power - W	Torque - N·m	Frequency - Hz	Speed - m/s	Density - kg/m^3	Electric potential - W/A	Electric resistance - V/A	Electric charge - C	Others - use symbols
1. Baker DOT No. 526.781	0	0	0	0	X	X	X	0	0	0	-	-	-	-	-	X	-	X	-	-	-	-
2. Casket Assembler DOT No. 739.781	0	0	X	X	X	X	X	0	0	0	-	-	-	-	-	-	-	X	-	-	-	-
3. Fabricator and Metal Assembler DOT No. 809.381	0	0	0	0	0	X	X	0	0	X	0	0	0	0	0	0	0	X	X	X	X	X
4. Furniture Designer DOT No. 142.081	*	*	0	X	X	X	X	0	X	X	X	0	X	X	X	-	-	0	-	-	-	-
5. Pulp and Paper Tester DOT No. 539.384	0	0	0	0	X	X	X	0	0	0	X	X	X	X	X	X	X	X	-	-	-	-
6. Machinist DOT No. 600.280	0	0	0	0	0	X	X	0	0	0	0	0	0	0	0	X	X	X	0	0	0	0

Levels of Competency

Level 1: -

Level 2: X

Level 3: 0

Level 4: *

Occupation	METRIC STANDARDS																																		
	Base quantities and units	Building construction	Chains and lifting hooks	Conduit	Containers and packages	Drafting, design and tolerance data	Electrical machines and apparatus	Home cooking and baking	Laboratory glassware	Machine elements	Pins	Rivets	Rollers, chains	Shafts and keys	V belts and accessories	Machine tool data	Materials	Angles and bar stock	Paper	Sheet metal and wire	Timber and plywood	Medical devices	Pallets and pallet trucks	Pipe threads	Refrigeration	Antifriction bearing	Ball and cylindrical rollers	Thrust	Tapered	Accessories	Engineering data	Screw threads	Tap and clearance drills	Threaded fasteners	Tools and Tooling
1. Baker DOT No. 526.781	0	-	-	-	0	-	X	0	-	-	-	-	-	-	X	-	X	-	X	-	-	-	X	-	0	-	-	-	-	X	-	-	-	-	-
2. Casket Assembler DOT No. 739.781	X	0	0	-	-	X	X	-	-	X	X	X	X	-	X	X	0	-	-	-	0	-	X	-	-	-	-	-	-	X	-	X	X	0	X
3. Fabricator and Metal Assembler DOT No. 809.381	0	X	X	0	X	0	0	-	-	0	0	0	0	0	0	0	0	0	-	0	X	-	-	X	-	X	X	X	X	0	X	0	0	0	0
4. Furniture Designer DOT No. 142.081	*	X	X	X	X	*	X	-	-	-	-	-	-	-	-	X	*	X	X	0	*	-	X	X	-	X	X	X	X	X	X	X	X	X	X
5. Pulp and Paper Tester DOT No. 539.384	0	X	-	-	0	0	X	X	0	-	-	-	-	-	-	-	0	X	X	-	-	-	-	-	-	-	0	-	-	0	0	-	-	-	X
6. Machinist DOT No. 600.280	0	-	0	X	-	0	0	-	-	0	0	0	0	0	0	0	0	0	0	0	-	-	-	-	-	0	0	0	0	0	X	0	0	0	0

Level of Competency

Level 1: -

Level 2: X

Level 3: 0

Level 4: *

Occupation	APPLICATIONS																					
	Drafting scales	Drafting devices	Precision measuring tools	Machine conversion units	Drills, reamers and cutting tools	Wrenches	Weighing scales and devices	Liquid measuring devices	Temperature scales and devices	Thread cutting equipment	Pressure gages and devices	Fasteners	Consumer units	Electrical meters	Metal thickness gages	Metal hardness gages	Micrometer and vernier	Other measuring tools	Machine conversion units	Other cutting tools	Conversion to and from metrics	Metric math applications
1. Baker DOT No. 526.781	-	-	0	X	-	-	0	0	0	-	-	-	X	-	-	-	-	X	X	-	X	0
2. Casket Assembler DOT No. 739.781	0	X	0	0	0	X	-	-	-	X	-	0	X	-	X	-	-	0	X	0	0	0
3. Fabricator and Metal Assembler DOT No. 809.381	0	X	0	0	0	0	-	-	-	0	X	0	X	X	0	0	0	0	X	0	0	0
4. Furniture Designer DOT No. 142.081	*	*	*	*	0	X	X	-	X	X	X	*	X	X	*	*	X	0	0	0	*	0
5. Pulp and Paper Tester DOT No. 539.384	0	0	0	-	-	X	0	0	0	-	0	-	X	X	-	-	-	X	X	X	0	0
6. Machinist DOT No. 600.280	0	0	0	0	0	0	0	0	0	0	0	0	X	X	0	0	0	0	0	0	0	0

Section 2
Part C

CAREER CLUSTER - BUSINESS AND OFFICE

Level of Competency

Level 1: -
Level 2: X
Level 3: 0
Level 4: *

	BASE							DERIVED														
Occupation	Length - metre - m	Mass - kilogram - kg	Temperature - degrees Celsius - °C	Time - second - s	Electric current - ampere - A	Luminous intensity - candela - cd	Amount of substance - mole - mol	Area - m^2	Volume - m^3	Liquid capacity - litre	Force - N	Pressure and stress - Pa	Energy - J	Power - W	Torque - N·m	Frequency - Hz	Speed - m/s	Density - kg/m^3	Electric potential - W/A	Electric resistance - V/A	Electric charge - C	Others - use symbols
1. Administrative Asst. DOT No. 169.168	0	0	0	0	X	0	X	X	X	X	-	-	-	-	-	X	X	-	-	-	-	-
2. Administrative Secy. DOT No. 169.168	X	X	X	X	X	X	X	-	-	-	-	-	-	-	-	X	X	-	-	-	-	-
3. Account Information Clerk DOT No. 210.368	X	X	X	X	X	X	X	-	X	X	-	-	-	X	-	X	X	-	X	X	X	-
4. Programmer DOT No. 020.188	X	X	X	X	X	X	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
5. Head Teller DOT No. 212.138	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Levels of Competency

Level 1: -

Level 2: X

Level 3: 0

Level 4: *

Occupation	Base quantities and units	Building construction	Chains and lifting hooks	Conduit	Containers and packages	Drafting, design and tolerance data	Electrical machines and apparatus	Home cooking and baking	Laboratory glassware	Machine elements	Pins	Rivets	Rollers, chains	Shafts and keys	V belts and accessories	Machine tool data	Materials	Angles and bar stock	Paper	Sheet metal and wire	Timber and plywood	Medical devices	Pallets and pallet trucks	Pipe threads	Refrigeration	Antifriction bearing	Ball and cylindrical rollers	Thrust	Tapered	Accessories	Engineering data	Screw threads	Tap and clearance drills	Threaded fasteners	Tools and Tooling
	METRIC STANDARDS																																		
1. Administrative Asst. DOT No. 169.168	-	-	-	-	X	-	X	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2. Administrative Secy. DOT No. 169.168	-	-	-	-	X	-	X	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3. Account Information Clerk DOT No. 210.368	X	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4. Programmer DOT No. 020.188	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
5. Head Teller DOT No. 212.138	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Level of Competency

Level 1: -

Level 2: X

Level 3: O

Level 4: *

Occupation	Drafting scales	Drafting devices	Precision measuring tools	Machine conversion units	Drills, reamers and cutting tools	Wrenches	Weighing scales and devices	Liquid measuring devices	Temperature scales and devices	Thread cutting equipment	Pressure gages and devices	Fasteners	Consumer units	Electrical meters	Metal thickness gages	Metal hardness gages	Micrometer and vernier	Other measuring tools	Machine conversion units	Other cutting tools	Conversion to and from metrics	Metric math applications
1. Administrative Asst. DOT No. 169.168	-	-	-	-	-	-	-	-	X	-	-	-	X	-	-	-	-	-	-	-	X	-
2. Administrative Secy. DOT No. 169.168	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	X	-
3. Account Information Clerk DOT No. 210.188	-	-	-	-	-	-	-	-	X	-	X	-	X	X	-	-	-	-	-	-	X	-
4. Programmer DOT No. 020.188	-	-	-	X	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	*	-
5. Head Teller DOT No. 212.138	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Section 2
Part D

CAREER CLUSTER - HEALTH

Level of Competency

Level 1: -
Level 2: X
Level 3: 0
Level 4: *

	BASE							DERIVED														
Occupation	Length - metre - m	Mass - kilogram - kg	Temperature - degrees Celsius - °C	Time - second - s	Electric current - ampere - A	Luminous intensity - candela - cd	Amount of substance - mole - mol	Area - m^2	Volume - m^3	Liquid capacity - litre	Force - N	Pressure and stress - Pa	Energy - J	Power - W	Torque - N·m	Frequency - Hz	Speed - m/s	Density - kg/m^3	Electric potential - W/A	Electric resistance - V/A	Electric charge - C	Others - use symbols
1. Contact Lense Tech. DOT No: 299.478	*	*	0	0	0	*	X	*	0	0	0	*	*	*	0	0	*	*	*	*	*	
2. Inhalation Therapist DOT No: 079.368	*	*	*	*	0	0	0	*	*	*	*	*	0	0	0	*	0	*	0	0	0	
3. Medical Laboratory Assistant DOT No: 078.381	*	*	*	*	*	0	*	0	*	*	0	*	*	*	0	*	X	*	X	X	X	
4. Nurse General Duty DOT No: 075.378	*	*	*	*	*	*	*	*	*	*	0	*	*	*	0	*	0	*	0	0	0	
5. Dental Hygenist DOT No: 078.368	*	*	*	*	*	*	0	*	*	*	*	*	*	*	0	*	*	*	*	*	*	

Levels of Competency

Level 1: -

Level 2: X

Level 3: 0

Level 4: *

Occupation	Base quantities and units	Building construction	Chains and lifting hooks	Conduit	Containers and packages	Drafting, design and tolerance data	Electrical machines and apparatus	Home cooking and baking	Laboratory glassware	Machine elements	Pins	Rivets	Rollers, chains	Shafts and keys	V belts and accessories	Machine tool data	Materials	Angles and bar stock	Paper	Sheet metal and wire	Timber and plywood	Medical devices	Pallets and pallet trucks	Pipe threads	Refrigeration	Antifriction bearing	Ball and cylindrical rollers	Thrust	Tapered	Accessories	Engineering data	Screw threads	Tap and clearance drills	Threaded fasteners	Tools and Tooling
1. Contact Lense Tech. DOT No. 299.478	*	-	-	-	*	*	0	X	0	X	0	0	0	0	0	0	0	-	0	X	-	*	-	-	0	-	-	-	-	X	0	*	*	*	*
2. Inhalation Therapist DOT No. 079.368	*	-	-	-	*	X	0	X	*	X	0	0	0	0	0	0	0	-	0	X	-	*	-	-	*	-	-	-	-	X	0	0	0	0	0
3. Medical Laboratory Assistant DOT No. 078-381	*	-	-	-	*	X	0	0	*	X	0	0	0	0	0	0	0	-	0	X	-	*	-	-	*	-	-	-	-	X	0	0	0	0	0
4. Nurse General Duty DOT No. 075.378	*	-	-	-	*	0	X	*	0	-	-	-	-	-	-	-	-	-	0	-	-	0	-	-	0	-	-	-	-	-	-	X	0	-	-
5. Dental Hygenist DOT No. 078.368	*	-	-	-	*	X	*	0	*	X	0	0	0	0	0	0	0	-	0	X	-	*	-	-	-	-	-	-	-	X	0	0	0	0	0

Level of Competency

Level 1: -

Level 2: X

Level 3: 0

Level 4: *

	APPLICATIONS																					
Occupation	Drafting scales	Drafting devices	Precision measuring tools	Machine conversion units	Drills, reamers and cutting tools	Wrenches	Weighing scales and devices	Liquid measuring devices	Temperature scales and devices	Thread cutting equipment	Pressure gages and devices	Fasteners	Consumer units	Electrical meters	Metal thickness gages	Metal hardness gages	Micrometer and vernier	Other measuring tools	Machine conversion units	Other cutting tools	Conversion to and from metrics	Metric math applications
1. Contact Lense Tech. DOT No: 299.478	*	*	*	*	*	*	0	0	0	*	0	*	*	0	*	0	*	0	0	X	*	*
2. Innalation Therapist DOT No: 079.368	0	0	0	0	0	0	0	0	*	0	*	0	*	*	0	0	0	0	X	X	*	*
3. Medical Laboratory Assistant DOT No: 078-381	0	0	0	0	0	0	0	0	*	0	*	0	*	*	0	0	0	0	X	X	*	*
4. Nurse General Duty DOT No: 075.378	-	-	-	-	-	-	0	0	*	-	X	-	*	0	-	-	-	0	-	-	0	*
5. Dental Hygenist DOT No: 078.368	0	0	0	0	0	0	0	0	*	X	0	0	*	0	0	0	0	0	X	X	X	*

Section 2
Part E

CAREER CLUSTER - CONSTRUCTION

Level of Competency

Level 1: -
Level 2: X
Level 3: 0
Level 4: *

	BASE							DERIVED														
Occupation	Length - metre - m	Mass - kilogram - kg	Temperature - degrees Celsius - °C	Time - second - s	Electric current - ampere - A	Luminous intensity - candela - cd	Amount of substance - mole - mol	Area - m^2	Volume - m^3	Liquid capacity - litre	Force - N	Pressure and stress - Pa	Energy - J	Power - W	Torque - N·m	Frequency - Hz	Speed - m/s	Density - kg/m^3	Electric potential - W/A	Electric resistance - V/A	Electric charge - C	Others - use symbols
1. Carpenter Foreman DOT No. 860.131-018	*	*	*	*	*	-	-	*	*	*	*	*	X	0	0	*	0	*	0	*	0	
2. Bricklayer DOT No. 861.381	0	0	0	-	X	-	-	0	X	0	X	-	-	-	X	0	-	-	-	-	-	
3. Electrical Distribution Checker DOT No. 824.281-010	*	*	*	*	*	0	-	*	*	*	0	0	X	*	X	*	*	-	*	*	*	
4. Plumber DOT No. 962.381	0	0	0	-	X	-	-	0	0	0	X	-	-	-	-	0	-	-	-	-	-	
5. Painter DOT No. 840.781	0	0	0	-	-	-	-	0	0	0	-	-	-	-	-	0	-	-	-	-	-	

Levels of Competency
Level 1: -
Level 2: X
Level 3: 0
Level 4: *

	METRIC STANDARDS																																		
Occupation	Base quantities and units	Building construction	Chains and lifting hooks	Conduit	Containers and packages	Drafting, design and tolerance data	Electrical machines and apparatus	Home cooking and baking	Laboratory glassware	Machine elements	Pins	Rivets	Rollers, chains	Shafts and keys	V belts and accessories	Machine tool data	Materials	Angles and bar stock	Paper	Sheet metal and wire	Timber and plywood	Medical devices	Pallets and pallet trucks	Pipe threads	Refrigeration	Antifriction bearing	Ball and cylindrical rollers	Thrust	Tapered	Accessories	Engineering data	Screw threads	Tap and clearance drills	Threaded fasteners	Tools and Tooling
1. Carpenter Foreman DOT No. 860.131-018	0	*	*	*	X	0	X	-	-	X	*	*	X	X	X	-	0	-	-	0	*	-	-	*	-	-	-	-	-	-	*	X	X	X	-
2. Bricklayer DOT No. 861.381	0	0	X	X	X	X	-	-	-	X	-	-	-	-	X	-	0	X	-	X	X	-	-	-	-	-	-	-	-	-	0	X	X	X	-
3. Electrical Distribution Checker DOT No. 824.281-010	*	0	-	*	0	0	*	-	-	X	-	-	-	-	-	-	*	-	-	*	-	X	-	-	-	-	-	-	-	-	*	X	X	X	-
4. Plumber DOT No. 862.381	0	0	X	-	X	X	-	-	-	X	-	-	X	-	X	-	0	X	-	X	X	-	-	0	-	-	-	-	-	-	0	X	X	X	-
5. Painter DOT No. 840.781	0	X	-	-	X	-	-	-	-	-	-	-	-	-	X	-	X	-	-	-	X	-	-	-	-	-	-	-	-	-	0	X	-	X	-

Level of Competency

Level 1: -

Level 2: X

Level 3: 0

Level 4: *

	APPLICATIONS																				
Occupation	Drafting scales	Drafting devices	Precision measuring tools	Machine conversion units	Drills, reamers and cutting tools	Wrenches	Weighing scales and devices	Liquid measuring devices	Temperature scales and devices	Thread cutting equipment	Pressure gages and devices	Fasteners	Consumer units	Electrical meters	Metal thickness gages	Metal hardness gages	Micrometer and vernier	Other measuring tools	Machine conversion units	Other cutting tools	Conversion to and from metrics	Metric math applications
1. Carpenter Foreman DOT No. 860.131-018	*	*	*	*	0	*	0	0	0	0	0	*	*	0	0	X	X	*	0	0	*	*
2. Bricklayer DOT No. 861.381	-	-	-	-	X	0	-	-	-	-	-	0	0	-	-	-	-	X	-	-	0	0
3. Electrical Distribution Checker DOT No. 824.281-010	*	0	*	*	*	*	0	0	*	*	*	*	*	*	0	X	X	*	0	0	*	*
4. Plumber DOT No. 862.381	-	-	-	-	0	0	-	X	X	0	-	0	0	-	-	-	-	X	-	-	0	0
5. Painter DOT No. 840.781	-	-	-	-	-	X	X	0	0	-	-	0	-	-	-	-	-	X	-	-	0	0

Section 2

Part F

TEACHING-LEARNING MODULE
METRICS IN CARPENTRY*

INTRODUCTION

With the eventual conversion of American industry to the metric system, the area of carpentry will be drastically changed. Since a hard conversion will change lumber and masonry sizes, an entire structure will have to be based on metric dimensions. Even a soft conversion will entail a basic understanding of metric principles. The material contained in this carpentry unit is intended to be supplementary to an existing carpentry program. This material does not show how to do the work, only how metric units may be substituted for conventional units.

A short history of measurement is suggested to begin the material as a base on which to build. Current employment possibilities are included to show the need for skill development in carpentry.

The first section gives exposure to the base units and how these are used to derive other metric units. Only those units considered important to carpentry are included. The many additional facets of metrication should be pursued in other more comprehensive materials.

The second section cites typical examples of situations in which the carpenter would need metric measurements to follow drawings and specifications. General and specific objectives are given for each unit and a short test is provided for use at the conclusion of each unit.

A major responsibility of any carpenter is to read prints and build according to the plan. The third section, therefore, is an exercise in print reading. A set of plans are provided with all test questions taken from the drawings. This exercise is intended to build on the first two units and should not be used separately.

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*William K. Purdy, Woodworking Consultant

Following the exercises are suggested learning activities which allow simple applications of metric learning. Project ideas are provided starting with very basic items to the more complex. Instructor discretion according to time and facility is needed.

METRICS APPLIED TO BASIC CARPENTRY

COURSE OUTLINE	VISUALS	ACTIVITIES
History of Measurement	FS #1	
Planning, Introduction Job Information		
Base Units	TM 1, 2 & 3	Test I
Metre		Related Information
Kilogram		
Ampere		
Drafting Scales	TM 4	
Metric Modules	TM 5	
Temperature	TM 6	
Derived Units	TM 8	
Area		
Volume		
Litre		
Pascal		
Watt		
Volt		

FS #1 - Filmstrip, Introduction to SI
TM - Transparency masters made from Figures

METRICS APPLIED TO BASIC CARPENTRY Continued

COURSE OUTLINE	VISUALS	ACTIVITIES
Application		
Measuring Devices	TM 9 & 10	Test II Print Reading
Lumber Sizes	TM 11	
Lay Out	TM 12	
Panel Sizes	TM 13	Test III Application
Framing	TM 14	
Roof Framing	TM 15 & 16	
Stair Framing	TM 17	Construct Suggested Metric Projects

TM - Transparency masters made from Figures

RELATED INFORMATION FOR USE OF METRICS IN CARPENTRY

GENERAL OBJECTIVE

Upon completion of this unit the student will be able to identify the base and derived metric units. The student will also be able to state typical instances for use of the base and derived units in construction of a residence.

SPECIFIC OBJECTIVES

Upon completion of this unit, using metric measurement and terms, the student will be able to:

1. List the following base units:
    - A. metre
    - B. kilogram
    - C. ampere
    - D. kelvin
2. State what is measured by each of the above units
3. Cite specific construction principles affected by each of the above base units
4. List the following derived units:
    - A. m^2
    - B. m^3
    - C. litre
    - D. pascal
    - E. volt
    - F. watt
5. State what is measured by each of the above units
6. Cite specific construction principles affected by each of the above derived units
7. Differentiate between lumber cut to customary sizes and metric sizes
8. Identify panels manufactured to metric specifications
9. Convert customary sizes to metric sizes
10. Identify the metric module base for building houses
11. State recommended spacing for structural members of a building
12. State recommended module sizes for bricks and concrete blocks
13. Identify typical scale ratios used for drawing prints.

THE METRIC SYSTEM AS APPLIED TO ROUGH CARPENTRY

GENERAL OBJECTIVE

Upon completion of this unit the student will be able to identify a drawing stated in metric dimensions. The student will be able to take a metric drawing and construct the subject to metric sizes using tools with metric increments.

SPECIFIC OBJECTIVES

Upon completion of this unit, using metric tools and drawings, the student will be able to:

1. Identify metre, centimetre and millimetre divisions on metric scales
2. Take dimensions from the drawing and lay out corner stakes, batter boards and building lines
3. Determine grade lines and footing sizes
4. Construct forms for the footings
5. Determine size and construct the girder
6. Identify size of floor joists
7. Construct the floor joist pattern including the rough opening for stairs
8. Locate positions for walls and partitions
9. Determine stud spacing and location of door and window rough openings
10. Construct the walls and partitions
11. Differentiate between truss roof and conventional roof construction
12. Lay out and construct a truss
13. Lay out and cut common, hip, valley and jack rafters
14. Place and fasten trusses or rafters to metric centers
15. Determine size of stairway treads and risers
16. Lay out and cut a stair stringer
17. Lay out and cut exterior trim boards to specified metric sizes.

In the development of any house from the original drawing or plan, a basic planning allows for proper sequence of operation and minimal mistakes in the construction. In using metric dimensioning for building construction, the same holds true, that basic planning will result in increased production. It is, therefore, imperative that the carpenter understand the concepts involved in metric length measurement.

Base Units (Figure 2F-1, Chart on base units used throughout this unit)

The base unit for length in the metric system is called the metre. Figure 2F-2. The metre is further divided into 10 divisions called decimetres, each decimetre is divided into 10 centimetres and each centimetre is divided into 10 millimetres. These are illustrated clearly in Figure 2F-3.

In most instances when using plans or drawings, they will be drawn to scale. Common scales for building construction practices are reduction ratios such as 1:10, 1:20, 1:30, 1:50 or 1:100. Figure 2F-4. These scales are similar to the formerly used scales such as 1/2" to the foot, 1/4" to the foot or 1/8" to the foot.

Previously in customary work for building construction modules were used to standardize the building industry such as 16", 32", 48" and so forth. The same holds true in the metric system, however, the basis for all building construction will be a 100 millimetre module. Figure 2F-5. This also is called 1 decimetre. All standardized units for residential construction will be based on this 100 millimetre module. For instance, the distance between centers for studs in wall framing will be either 400 or 600 millimetres on center. Other units such as doors, windows, dry wall panels, plywood panels and insulation board panels will all be based on multiples of the 100 millimetre module.

While the unit of length is the most important item that the carpenter will have to know, there are other units that will be applicable to the construction of the house. One of these would be the unit which is used to measure mass. Figure 2F-1. This is called the kilogram. Formerly we referred to mass in the customary system as weight, however, a pound is truly a measure of mass rather than weight. In the metric system we refer to the kilogram as measuring the mass of a unit. Typical applications for use of this unit in residential construction would be measuring the amount of floor load exerted on a floor, the size of footings in particular types of soil to support the building and figuring snow loads for roof construction in snow areas. Another way that mass measurement would be used is in the use of jacks or supporting members underneath a building. The builder would have to know the capacity of raising and lowering devices such as screw jacks and hydraulic jacks.

Another unit that is the same in both the customary and metric system is the measurement of electrical current called the ampere. The carpenter will need to know what the service is that is coming into the house from the power company, and what type of temporary service he will have to have in order to operate his machinery during the basic construction. This unit will remain unchanged in conversion to the metric system.

The unit for temperature measurement is called the Celsius scale. Figure 2F-6. The Celsius scale is only a small portion of a larger scientific scale called the Kelvin scale. Degrees Celsius will be used in common practice to determine what temperature the atmosphere is outdoors for working conditions, or how the carpenter should properly dress. We will find that a very comfortable day will be in the vacinity of 70 degrees Fahrenheit. Figure 2F-7. Materials that we would use in construction which could be pertinent to temperature would be things such as adhesives, which must be maintained at particular temperatures, and paint, which many times will only spread at certain temperatures. Certainly the working temperature of concrete is such that if it is below freezing, chloride would have to be added to the water to keep the concrete from freezing while setting. A major item of importance for the architect in planning a house are the changes in temperature for heating, cooling and insulation needs. These would all be determined in degrees Celsius.

Derived Units (Figure 2F-8)

The above units of length, mass, electrical current and temperature are all referred to as base units. All other units used for measurement are called derived units, which means one or more of the base units are used to determine the derived units. The first of these the carpenter would need to be concerned with is the unit for area, simply taken from the linear measurement called metre squared or square metre. In the case of using area measurement, you would need to know such things as the size of the floor space for a structure, commonly measured in conventional terms of square feet or square yards, now would be measured in square metres. Roofing, floor covering, plywood and other sheet materials will be measured in square metres. The formula for finding square metres is no different than it is in the customary system. Simply length times width (A = L [length] x W [width]).

The next logical unit following area is volume. In this case simply add height to area, and it becomes a three dimensional object measured in metres cubed or cubic metres. Some examples for use of cubic metre is the removal or addition of fill dirt, determining concrete needs and capacity of rooms for climate control. Gassious materials will be measured in cubic metres or litres including such items as liquid propane, butane and natural gas for service to the house. The unit used to measure liquid volume is called the litre. A litre properly defined is one cubic decimetre of liquid. Typical applications for use in the construction industry would be the capacity of pumps and well systems, septic systems, hot water heaters, water softeners and measurements of public utility water service coming into the house. All of these will be measured in the amount of litres they consume or hold.

The derived unit for use in measuring pressure is called the pascal. The way a pascal is derived is rather complex and need not be entered into here. It is enough to know that services which require pressure measurement are water pressures, such as the pressure coming into a home from a well system or from the city water supply. Also the hydrostatic pressure that exists against the foundation walls from water in the soil.

Earlier we described the unit of electrical current measurement as being ampere. However, in order to determine the amount of electrical usage a house will have, two more familiar units are included in the metric system. The first of these is the measurement for electromotive force called volts. Common electrical voltage in houses today is 120 to 240 volts.

Another electrical measurement is the watt. This unit has long been used to determine electrical consumption in electric motors, appliances and lighting fixtures.

SECTION TWO - APPLICATION

In the actual application of metric measurement to the construction site, the first step would be laying out the building stakes and lot lines. In most cases the tools used would be metric tapes, which are supplied in lengths of 3, 5, 15, 30 and 50 metres. Figure 2F-9. Also available are the wooden and metal folding rules in 2 metre lengths and a carpenter's framing square, which is marked in centimetres. Figure 2F-10.

Once the building lines are layed out and the excavation is completed, the carpenter would be called upon to construct forms for concrete footings or columns and walls. At this point the ability of the carpenter to take dimensions from a drawing and apply them to the site is critical. The builder should thoroughly understand the concept of length measurement and the different divisions of the metre.

It is of the utmost importance that the footings be constructed properly or the entire structure may be drastically affected. Once the footings are set and the base masonry for use in the foundation and footings is completed, it would now be the job of the carpenter to carry through with the super structure of the building. The skills needed for this rough carpentry remain unchanged as far as the work is concerned. The only item changing would be the units used to measure. In this case, as previously mentioned, the metre is the base unit. However, most measurement will be given in either millimetres or centimetres.

An item of great concern to the carpenter is what lumber sizes are available as far as metric sizes are concerned. Figure 2F-11. The accompanying transparency describes comparatively how metric dimensions for lumber and conventional dimensions look. It is the job of the carpenter to determine what lumber sizes are available, and what he is intending to use on the job. It will be assumed throughout the rest of this material that metric sizes are available in standard construction lumber.

In the laying out of the floor plan, floor joists will be placed on 400 millimetre centers, which is very close to the former 16 inches on center. Figure 2F-12. During the framing of the floor structure it again is imperative that the carpenter know the sizes for rough openings of stairways and fireplaces. During the construction the carpenter must make proper allowances for the thickness of the structural members. Formerly, 1 1/2 inches for each individual joist was common. In the metric system thickness will be 35 millimetres, which is slightly less than 1 1/2 inches. Should the proper compensation not be made, the carpenter will wind up too short or too long in a particular space. This would be especially true for heading a stair or fireplace opening.

Floor decking and sheathing materials will come in a 1200 x 2400 millimetre module. Figure 2F-13. This being the case the 400 millimetre spacing for floor joists would work out just right for the 1200 and 2400 millimetre lengths of the plywood.

In framing the walls and partitions of the structure it will be necessary to know the length of studs that will be precut for the assembly of the wall. Figure 2F-14. Most likely the length of a precut stud will be 2300 millimetres to accomodate a 2400 millimetre panel. This will allow 105 millimetres for the thickness of the double top plate and the sole plate for a total of 2405 millimetres giving a 5 millimetre tolerance for the 2400 millimetre panel. the spacing of studs will probably be 400 or 600 millimetres, which is equivalent to the old 16 or 24 inches respectively. Here again, it is important for the carpenter to know room sizes and have the ability to take these sizes from the plan and lay out the sub floor for partitions and walls.

Once the walls and partitions are completed, the next logical structure would be framing the roof. At this point the carpenter will need to determine whether the roof is to be conventionally framed with rafters and ceiling joists or framed with a truss-type construction. Since in most cases truss construction is done by a manufacturer, and the trusses are taken to the job, it would be the job of the carpenter to simply order and erect them. Figure 2F-15. In the case of a conventionally framed roof, it will be the job of the carpenter not only to determine what type of framing the roof will have, but to size and cut these materials. Formerly the carpenter could refer to a framing square to determine length of rafters. Figure 2F-16. Since no rafter tables for the metric system exist, rafter lengths will now be determined using the Pythagorean Therom, which is simply finding the hypotenuse of a right triangle. This procedure is illustrated on the accompanying transparency. Determining spacing for rafters or trusses will be similar to the layout of spacing for floor joists and studs.

Another item of importance is the framing of the stairs. Figure 2F-17. It would be the responsibility of the layout carpenter to determine what the rise and run for the stairway would be, and then lay out the stringer for the proper cutting. This is illustrated on the accompanying transparency.

Miscellaneous items under the rough construction area would be such things as wall sheathing, which would be the same as floor and roof decking in the 1200 x 2400 module.

Exterior trim in most cases will be simply a matter of taking stock materials and cutting them to trim out the house according to the plan. The only critical item here is that the carpenter have the ability to take metric measurements from the drawings or from the existing structure and cut and fit trim boards to these metric sizes.

Figure 2F-1

INTERNATIONAL SYSTEM OF UNITS

SI

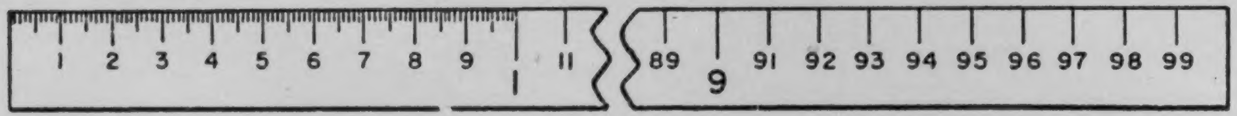
SEVEN BASE UNITS - SYMBOL - MEASUREMENT

1. metre	m	Length
2. kilogram	kg	Mass
3. second	s	Time
4. ampere	A	Electric Current
5. kelvin	K	Temperature
6. candela	cd	Luminous Intensity
7. mole	mol	Amount of Substance

Figure 2F-2

LENGTH

Metre m

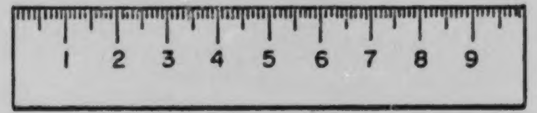

1
2
3
4
5
6
7
8
9
1
11
89
9
91
92
93
94
95
96
97
98
99

BASE UNIT

1 metre m

one tenth metre

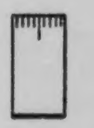
1/10 m or 0.1 m



1 decimetre dm

one hundredth metre

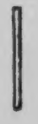
1/100 m or 0.01 m



1 centimetre cm

one thousandth metre

1/1000 m or 0.001 m



1 millimetre mm

Figure 2F-3

PREFIXES, EXPONENTS, and SYMBOLS

Decimal Form	Exponent	Prefix	Pronunciation	Symbol	Meaning
1 000	$= 10^{3}$	kilo	kĭl′ ō	k	thousand
100	$= 10^{2}$	hecto	hĕk′ tō	h	hundred
10	$= 10^{1}$	deka	dĕk′ â	da	ten
1					base unit
0.1	$= 10^{-1}$	deci	dĕs′ ī	d	tenth
0.01	$= 10^{-2}$	centi	sĕn′ tĭ	c	hundredth
0.001	$= 10^{-3}$	milli	mĭl ĭ	m	thousandth

Figure 2F-4

SCALE SELECTION FOR HOUSE CONSTRUCTION

METRIC mm/mm	CUSTOMARY inch/inch	USE
1:1	12:12	full size
1:2	6:12	half size
1:3	4:12	third size
1:5	3:12	quarter size** Details
1:10	1:12	1" = 1' - 0" **
1:20	3/4:12	3/4" = 1' - 0" ** Construction Details
1:25	1/2:12	1/2" = 1' - 0" ** Construction Details
1:50	1/4:12	1/4" = 1' - 0" ** Plans, Elevations, Sect.
1:100	1/8:12	1/8" = 1' - 0" ** Plot Plans
1:200	1/16:12	1/16" = 1' - 0" **
1:500	1/32:12	1/32" = 1' - 0" ** Site Plans
1:1250	1:1267	50 " = 1 mile**
1:2500	1:2534	25" = 1 mile** Site Maps

** Approximate Conversion

Figure 2F-5

PROPOSED METRIC MODULES FOR BUILDING MATERIALS

ITEM	SIZE
Concrete Blocks	190 x 290 x 390 190 x 190 x 390 10 mm mortar joint
Bricks	57 x 90 x 190 Face & Common 50 x 90 x 290 Roman
Floor Joists	35 x 230 35 x 280
Studs and Framing Lumber	35 x 90
Rafters	35 x 140
Panel Size	1200 x 2400
Door Sizes	600, 700, 800, 900, 1000 x 2100 internal 900, 1000, 1500, 1800, 2400 x 2100, 2400 or 2700 external
Windows	100 mm module multiples

Figure 2F-6

Temperature Measurement Systems

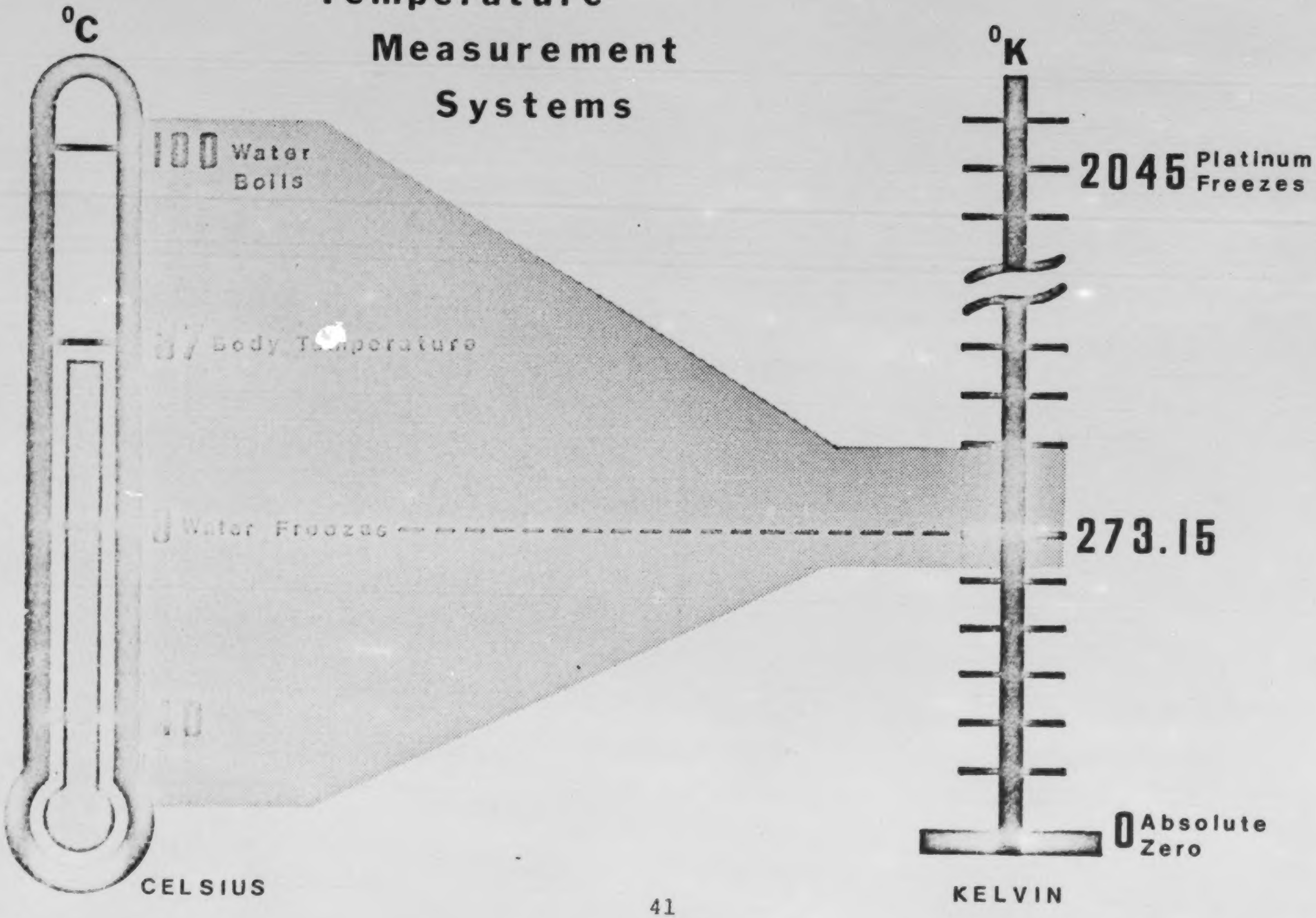
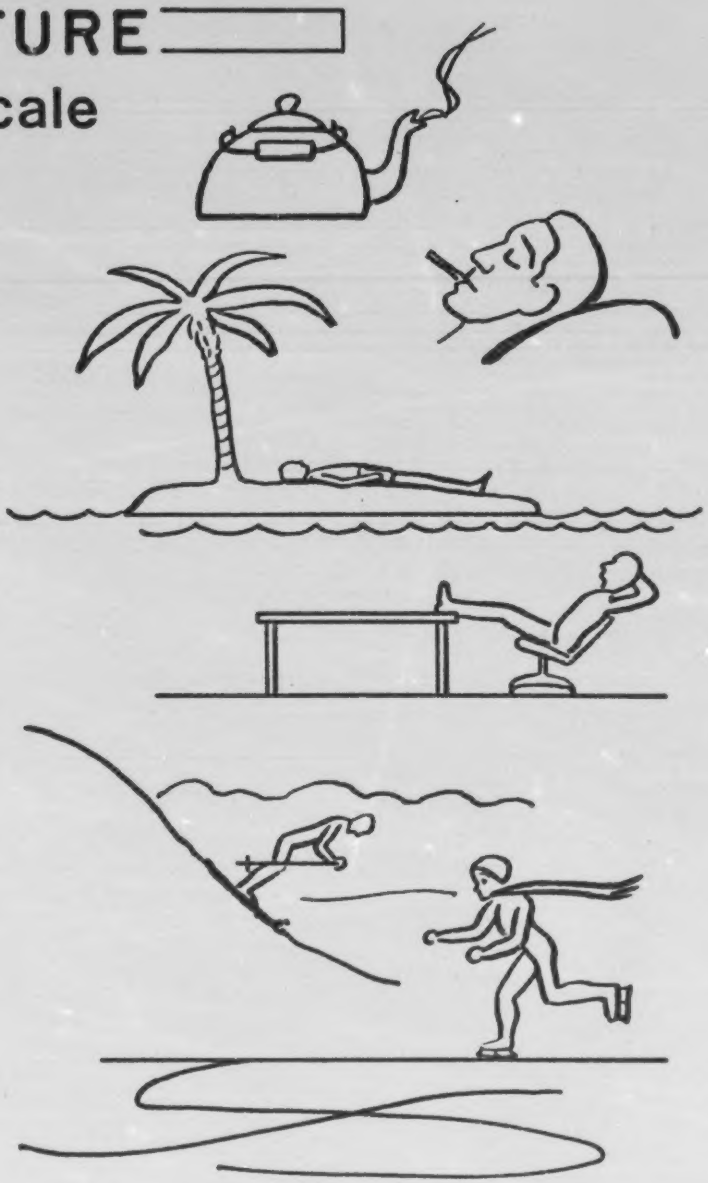

°C
100 Water Boils
37 Body Temperature
0 Water Freezes
10
CELSIUS
°K
2045 Platinum Freezes
273.15
0 Absolute Zero
KELVIN

Figure 2F-7

TEMPERATURE

Celsius Scale

100	Boiling Point (water)
40	High Fever
37	Normal Body Temperature
30	Quite Warm
22	Air Conditioned Building
20	Mild Spring Day
10	Warm Winter Day
5	Skiing
0	Freezing
-5	Icicles
-30	Bitter Cold



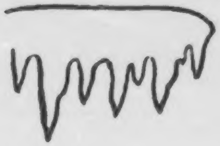
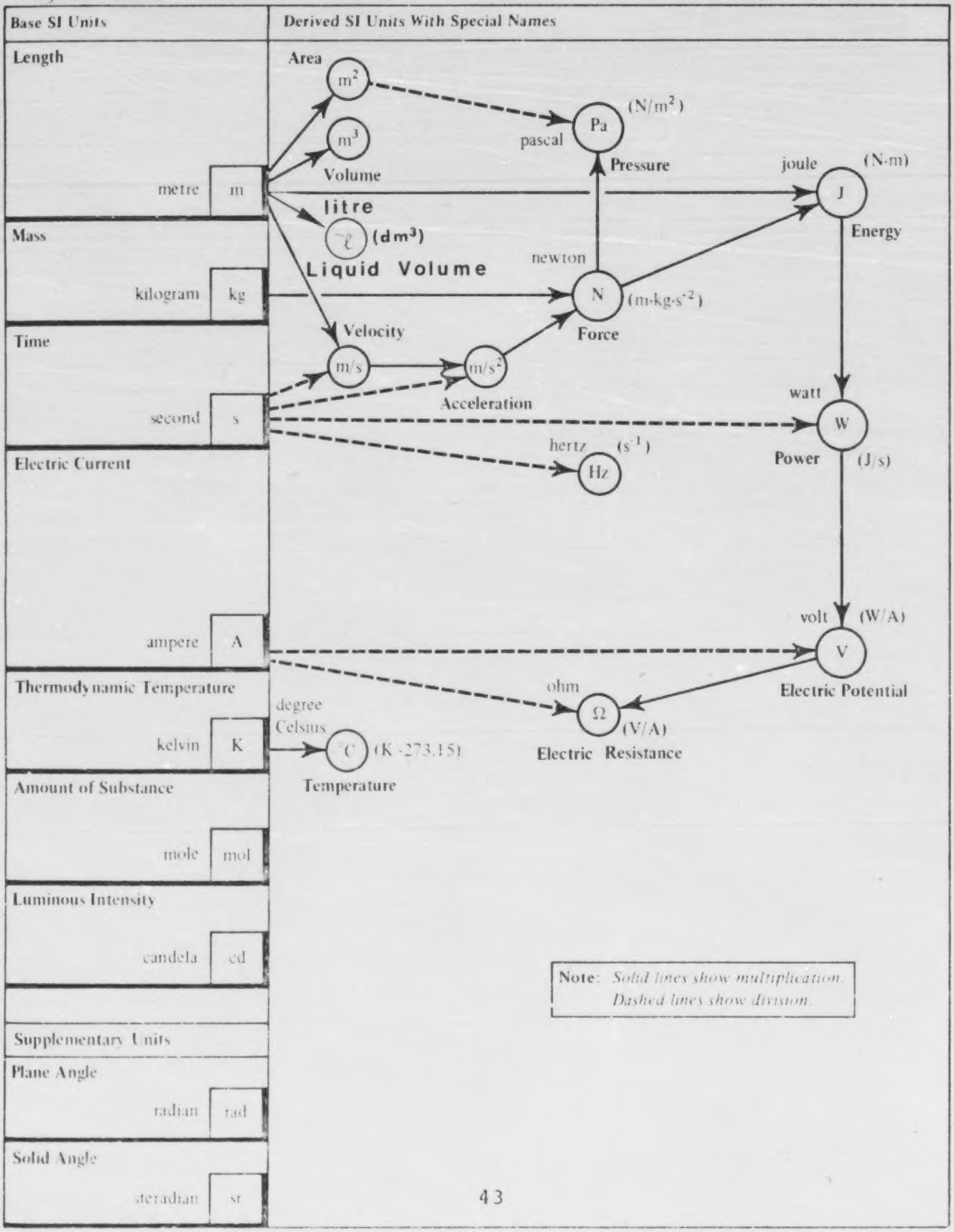


Figure 2F-8


Base SI Units
Derived SI Units With Special Names
Length
metre
m
Mass
kilogram
kg
Time
second
s
Electric Current
ampere
A
Thermodynamic Temperature
kelvin
K
Amount of Substance
mole
mol
Luminous Intensity
candela
cd
Supplementary Units
Plane Angle
radian
rad
Solid Angle
steradian
sr
Area
m^2
m^3
Volume
litre
ℓ
(dm^3)
Liquid Volume
Velocity
m/s
m/s^2
Acceleration
pascal
Pa
(N/m^2)
Pressure
newton
N
($m \cdot kg \cdot s^{-2}$)
Force
joule
J
($N \cdot m$)
Energy
watt
W
Power
(J/s)
hertz
Hz
(s^{-1})
volt
V
(W/A)
Electric Potential
ohm
Ω
(V/A)
Electric Resistance
degree Celsius
°C
(K -273.15)
Temperature

Note: *Solid lines show multiplication. Dashed lines show division.*

Figure 2F-9

METRIC TAPES

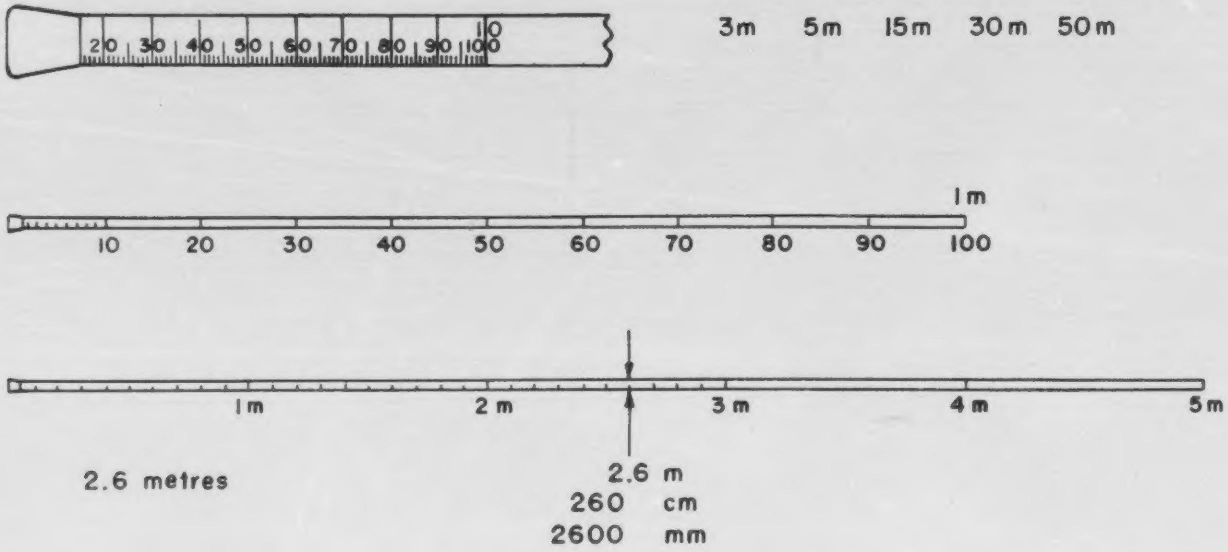
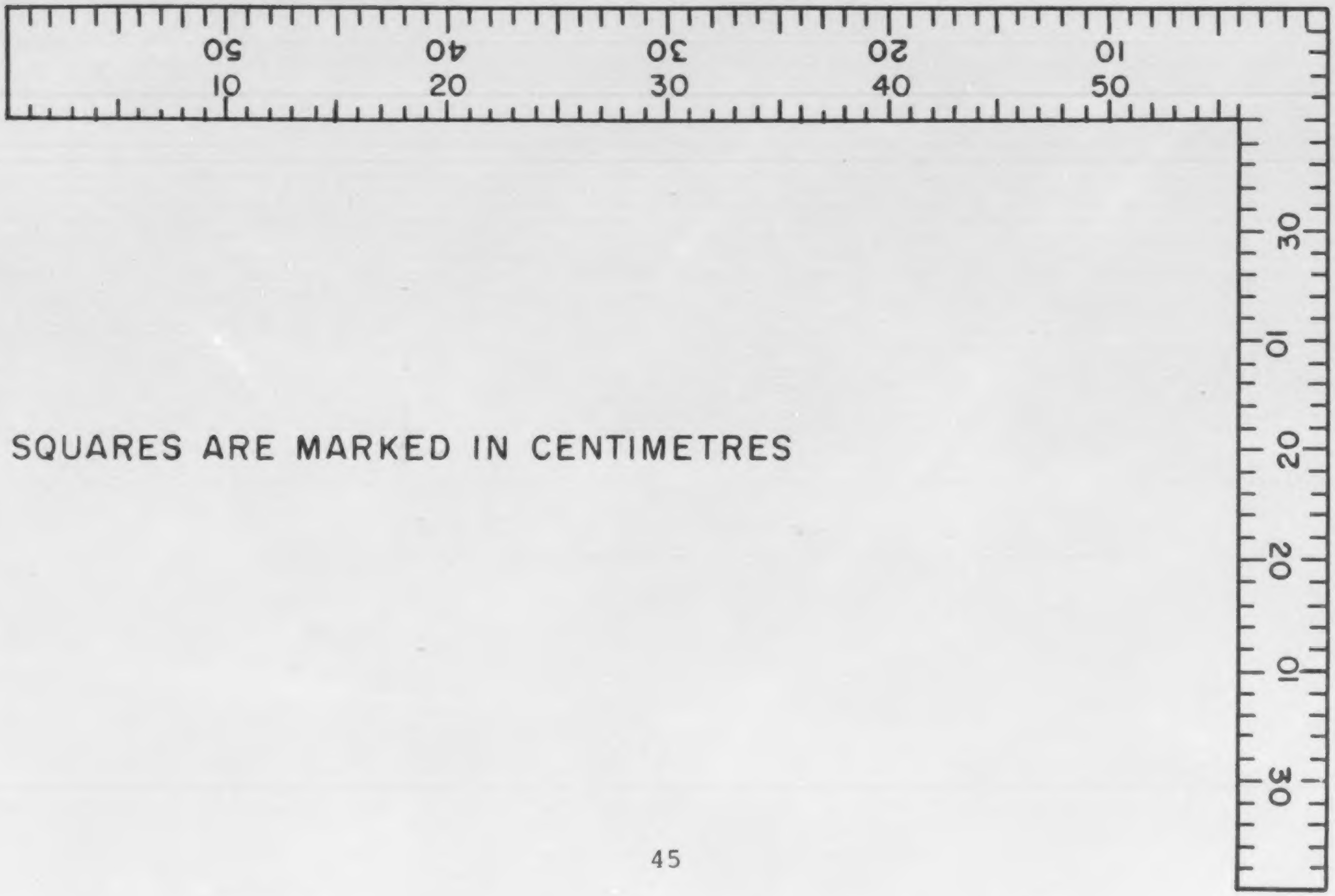

20 30 40 50 60 70 80 90 100 110
3m 5m 15m 30m 50m
1m
10 20 30 40 50 60 70 80 90 100
1m 2m 3m 4m 5m
2.6 metres
2.6 m
260 cm
2600 mm

Figure 2F-10

METRIC FRAMING SQUARE


50
40
30
20
10
10
20
30
40
50
30
10
20
20
10
30

SQUARES ARE MARKED IN CENTIMETRES

Figure 2F-11

COMPARISON CHART OF CUSTOMARY AND METRIC LUMBER SIZES

BASED ON WWP 1970 GRADING RULES

DIMENSION LUMBER

KEY	NOMINAL SIZE	UNSEASONED	DRY
Current Sizes Metric Conversion* Proposed Metric Size	2" x 4" 51 mm x 102 mm 50 mm x 100 mm	1 9/16" x 3 9/16" 40 mm x 91 mm	1 1/2" x 3 1/2" 38 mm x 89 mm 35 mm x 90 mm
Current Sizes Metric Conversion* Proposed Metric Size	2" x 6" 51 mm x 152 mm 50 mm x 150 mm	1 9/16" x 5 5/8" 40 mm x 143 mm	1 1/2" x 5 1/2" 38 mm x 140 mm 35 mm x 140 mm
Current Sizes Metric Conversion* Proposed Metric Size	2" x 8" 51 mm x 203 mm 50 mm x 200 mm	1 9/16" x 7 1/2" 40 mm x 191 mm	1 1/2" x 7 1/4" 38 mm x 184 mm 35 mm x 180 mm
Current Sizes Metric Conversion* Proposed Metric Size	2" x 10" 51 mm x 254 mm 50 mm x 250 mm	1 9/16" x 9 1/2" 40 mm x 241 mm	1 1/2" x 9 1/4" 38 mm x 235 mm 35 mm x 230 mm

*Approximation

COMPARISON CHART OF CUSTOMARY AND METRIC LUMBER SIZES

BASED ON WWP 1970 GRADING RULES

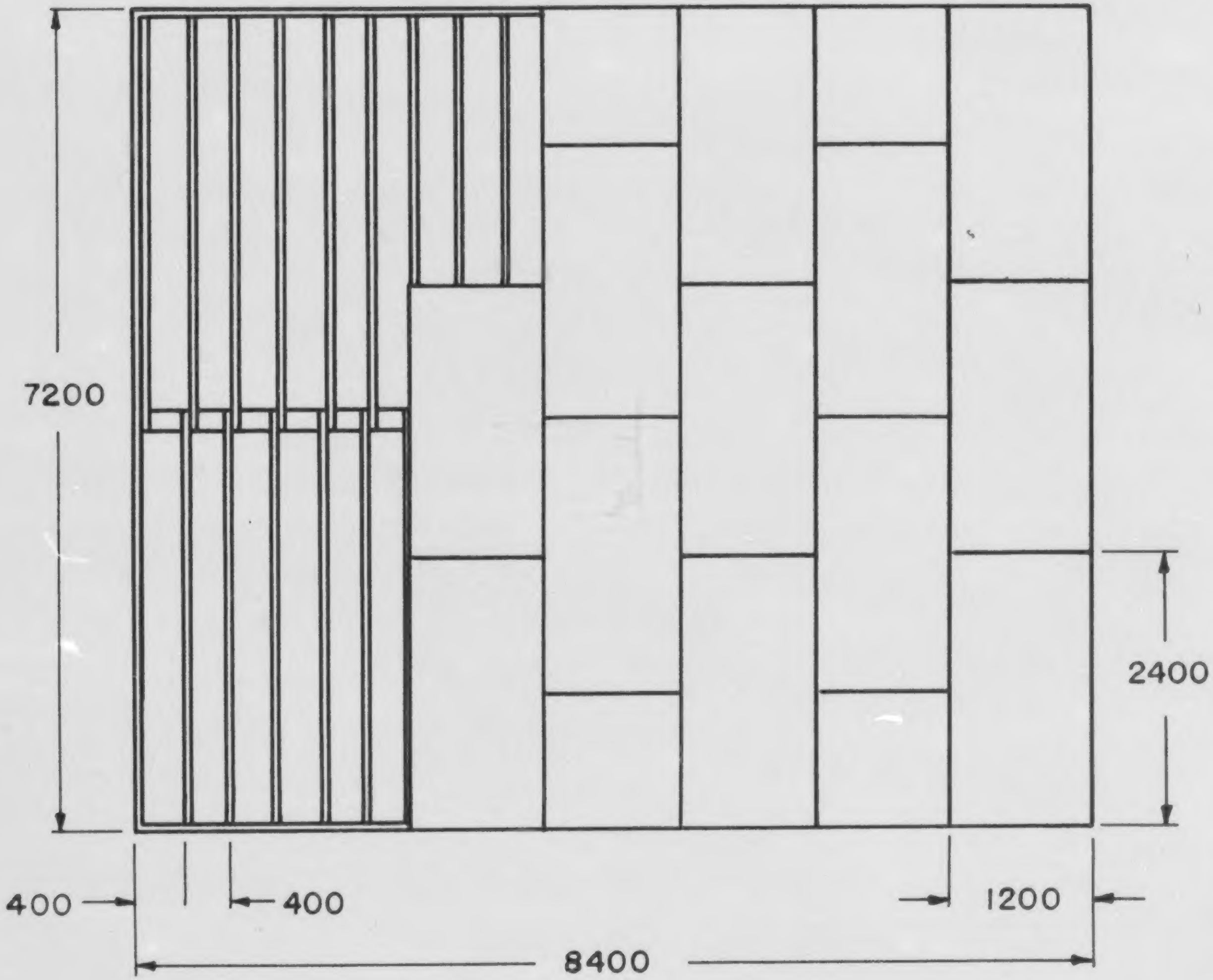
DIMENSION LUMBER

KEY	NOMINAL SIZE	UNSEASONED	DRY
Current Sizes	2" x 12"	1 9/16" x 11 1/2"	1 1/2" x 11 1/4"
Metric Conversion*	51 mm x 305 mm	40 mm x 292 mm	38 mm x 286 mm
Proposed Metric Size	50 mm x 300 mm		35 mm x 280 mm
Note: Widths for 1" lumber change similar to 2".	1" 25 25	25/32 19.8	3/4 19.1 19

*Approximation

Figure 2F-12

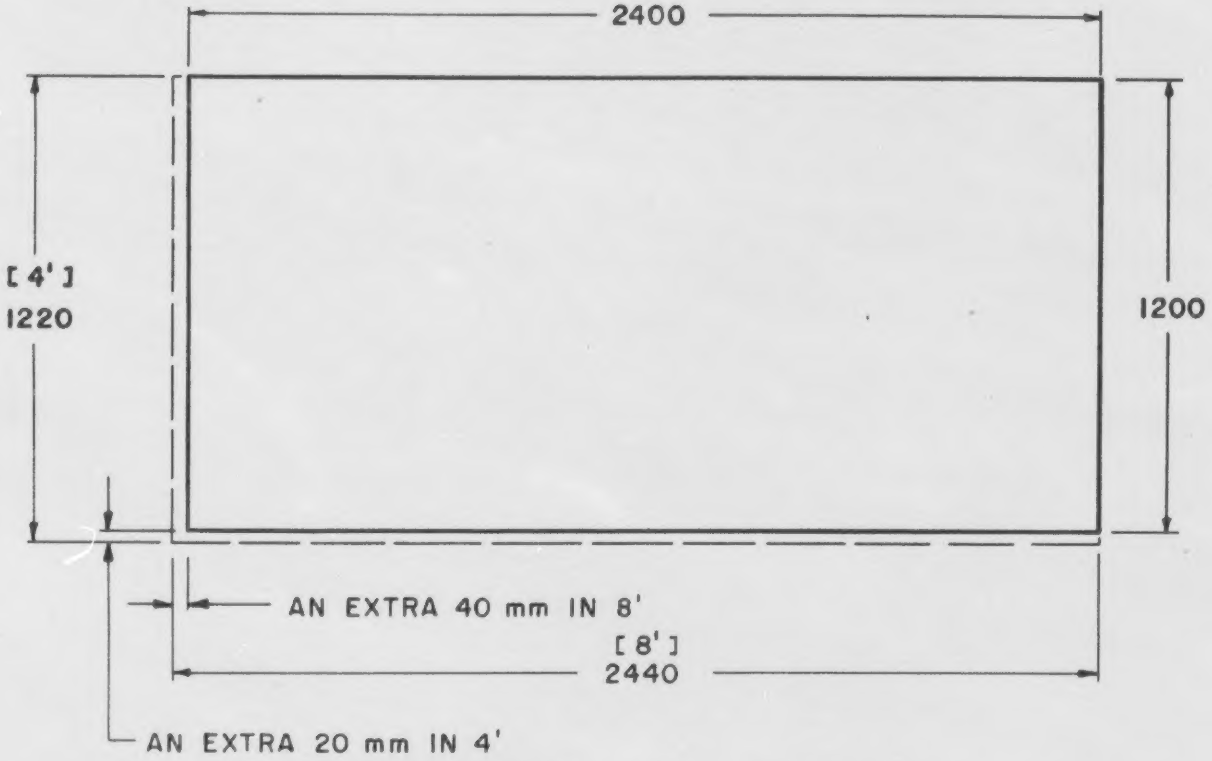
FLOOR JOIST PLAN


7200
2400
400
400
1200
8400

ALL DIMENSIONS IN mm

Figure 2F-13

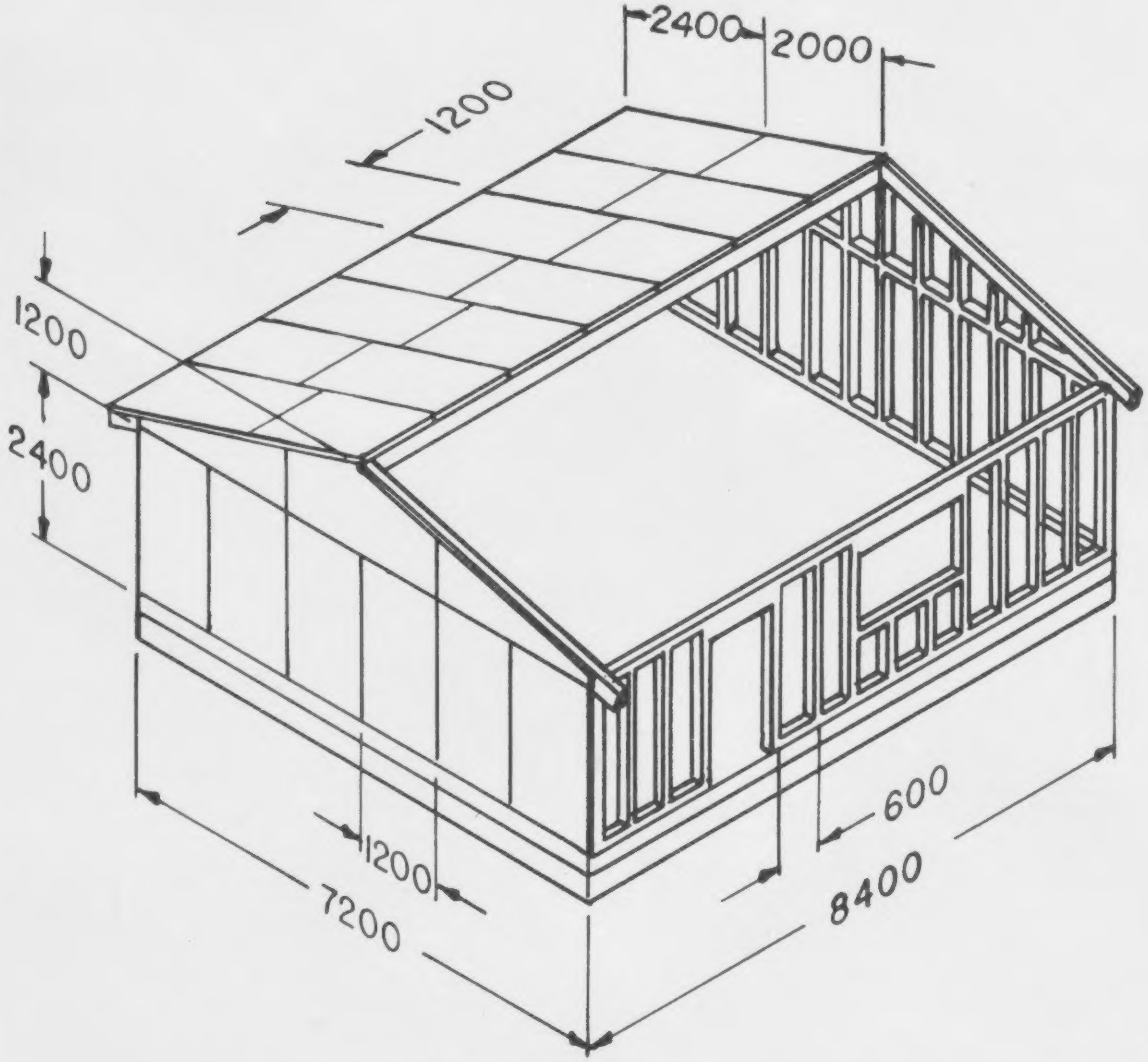
COMPARISON OF CONVENTIONAL AND PROPOSED PANEL SIZES FOR SHEET MATERIALS


2400
[4']
1220
1200
AN EXTRA 40 mm IN 8'
[8']
2440
AN EXTRA 20 mm IN 4'

ALL DIMENSIONS IN mm AND IN FEET

Figure 2F-14

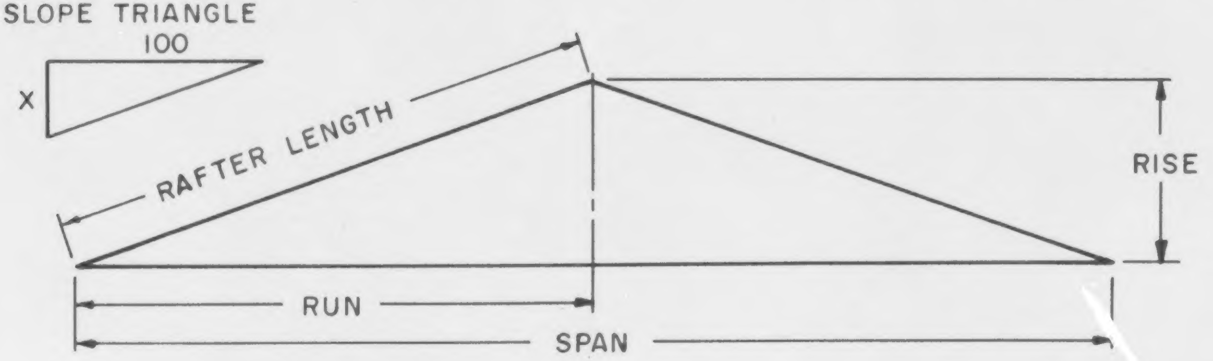
SMALL RESIDENCE IN METRIC


2400
2000
1200
1200
2400
600
1200
7200
8400

ALL DIMENSIONS IN mm

Figure 2F-15

PROPOSED METRIC RAFTER SIZING METHOD


SLOPE TRIANGLE
100
X
RAFTER LENGTH
RISE
RUN
SPAN

BASED ON 100 mm MODULE

100 mm = 1 DECIMETRE

SLOPE GIVEN IN mm RISE PER DECIMETRE OF RUN

PROBLEM

FIND THE RAFTER LENGTH FOR A 50:100 SLOPE WITH A 7200 mm SPAN

RUN = 3600

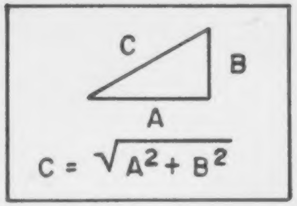
RISE PER DECIMETRE = 50

NUMBER OF DECIMETRES IN RUN 36

TOTAL RISE = 1800 → 50 X 36

RAFTER LENGTH = 4025 mm → $\sqrt{3600^2 + 1800^2}$

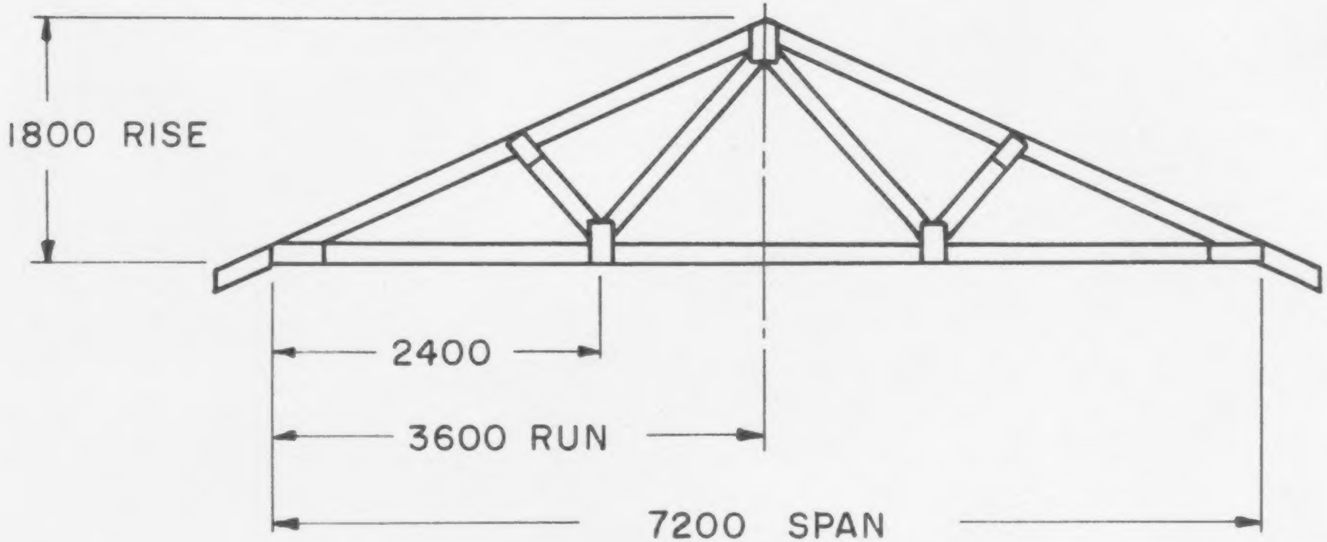
WHERE A = 3600
B = 1800



$C = \sqrt{A^2 + B^2}$

Figure 2F-16

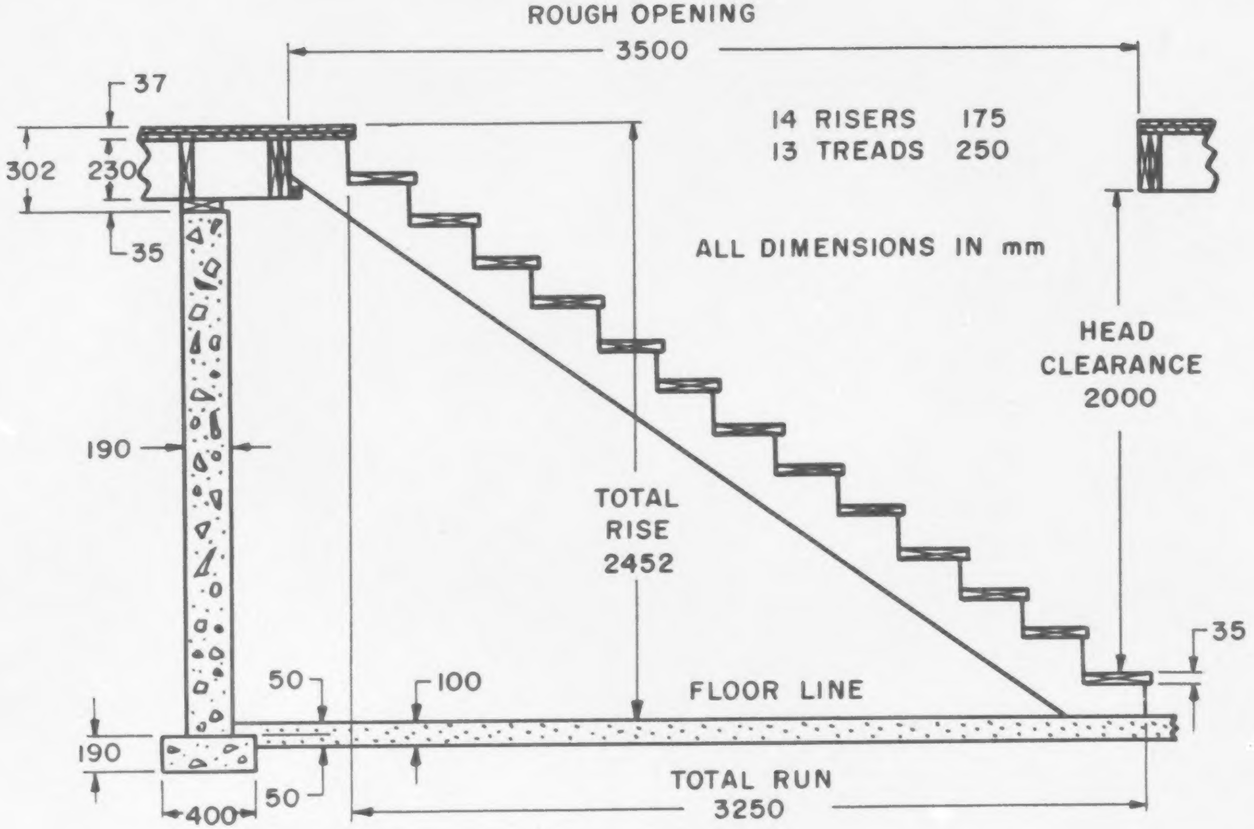
TYPICAL TRUSS DETAIL


1800 RISE
2400
3600 RUN
7200 SPAN

SCALE 1-50

ALL DIMENSIONS IN mm

Figure 2F-17



STAIR DETAIL

ROUGH OPENING
3500
37
302
230
35
14 RISERS 175
13 TREADS 250
ALL DIMENSIONS IN mm
HEAD
CLEARANCE
2000
190
TOTAL
RISE
2452
35
50
100
FLOOR LINE
190
50
400
TOTAL RUN
3250

Test 1

CARPENTRY TEST ON RELATED INFORMATION

Total Points 14

1. Which of the following metric units is the basis for length measurement?
    - A. kilogram
    - B. ampere
    - C. metre
    - D. litre
2. State the base unit used for mass measurement in the metric system.
    - A. kilogram
    - B. ampere
    - C. metre
    - D. litre
3. Which of the following symbols is the proper symbol used to designate area measurement in the metric system?
    - A. dm^3
    - B. m^3
    - C. m^2
    - D. l^2
4. Which of the following metric measurement units is used to measure liquid volume?
    - A. kilogram
    - B. ampere
    - C. metre
    - D. litre
5. Which of the following units is used to measure the pressure of water storage systems?
    - A. kilograms per square centimetre
    - B. joules
    - C. watts
    - D. pascals
6. Which of the following electrical terms is NOT a standard metric term?
    - A. volt
    - B. watt
    - C. fusetat
    - D. ampere
7. Which of the following electrical characteristics is measured with amperes?
    - A. electromotive force
    - B. voltage
    - C. current
    - D. energy

8. When measuring air volume of a room for climate control, which of the following metric measurement items would be used?

A. dm^2
B. m^3
C. mm^3
D. km^2

9. In the customary system of measurement a 2" x 4" was actually 1 1/2" thick and 3 1/2" wide. What is the direct metric conversion of this size?

A. 50 mm x 100 mm
B. 51 mm x 102 mm
C. 40 mm x 91 mm
D. 38 mm x 89 mm

10. Which of the following is the proposed metric size of a plywood panel?

A. 1240 mm x 2440 mm
B. 1220 mm x 2440 mm
C. 1200 mm x 2400 mm
D. 2 m x 4 m

11. State the recommended spacing for floor joists in a residence?

A. 200 mm
B. 300 mm
C. 400 mm
D. 600 mm

12. In the customary system of measurement the module used as a basis for all residential construction was 16 inches. What will be the module for use in the metric system?

A. 10 millimetres
B. 100 centimetres
C. 100 millimetres
D. 1 metre

13. If a builder were planning to pour concrete, which of the following metric temperature measurements would indicate a need for chloride to be added to the water to prevent freezing?

A. 30 °C
B. 25 °C
C. 2 °C
D. -10 °F

14. In common parlance temperature will be measured in degrees Celsius for all metric temperature measurement. Which of the following base units is the basis for the Celsius temperature scale?

A. kilogram
B. kelvin
C. watt
D. joule

Test 2

CARPENTRY TEST - APPLICATION

Total Points 6

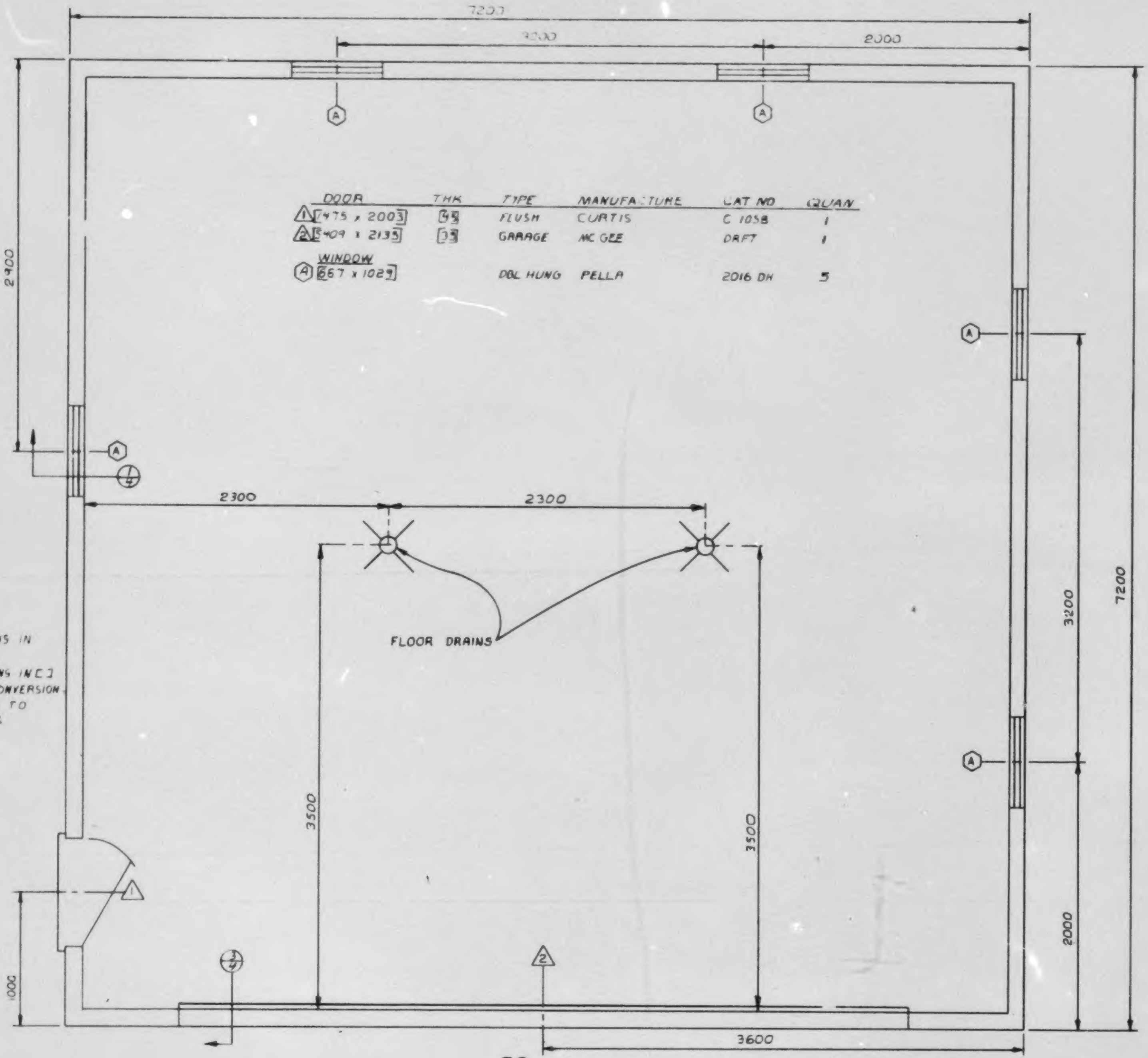
1. If the length of a plywood panel were given as 2.4 metres, which of the following would be the equivalent in centimetres?
    - A. 0.24 cm
    - B. 24 cm
    - C. 240 cm
    - D. 2400 cm
2. If a 2.4 metre plywood panel were to be cut exactly in the center of the long distance, state this dimension in millimetres?
    - A. 600 mm
    - B. 1200 mm
    - C. 2.4 mm
    - D. 12 mm
3. If the distance between centers for roof structural members is designated as 6 decimetres, which is the equivalent in millimetres?
    - A. 60 mm
    - B. 600 mm
    - C. 6 mm
    - D. 6000 mm
4. Which of the following is the metric equivalent in thickness and width of a customary 2" x 10" floor joist?
    - A. 50 x 100 mm
    - B. 51 x 254 mm
    - C. 38 x 286 mm
    - D. 35 x 280 mm
5. If a builder were building a home with a span of 7200 millimetres and a rise of 40 millimetres per decimetre of run, what would be the total rise in millimetres?
    - A. 3600 mm
    - B. 288 mm
    - C. 1440 mm
    - D. 400 mm
6. Given a stairway rough opening of 3500 millimetres and a total rise of 2452 millimetres, indicate the correct number of treads and risers using the standard metric tread and riser size of 175 millimetres for risers and 250 millimetres for tread.
    - A. 14 treads, 13 risers
    - B. 13 treads, 14 risers
    - C. 12 treads, 13 risers
    - D. 16 treads, 15 risers

Test 3

PRINT READING TEST ON METRIC GARAGE

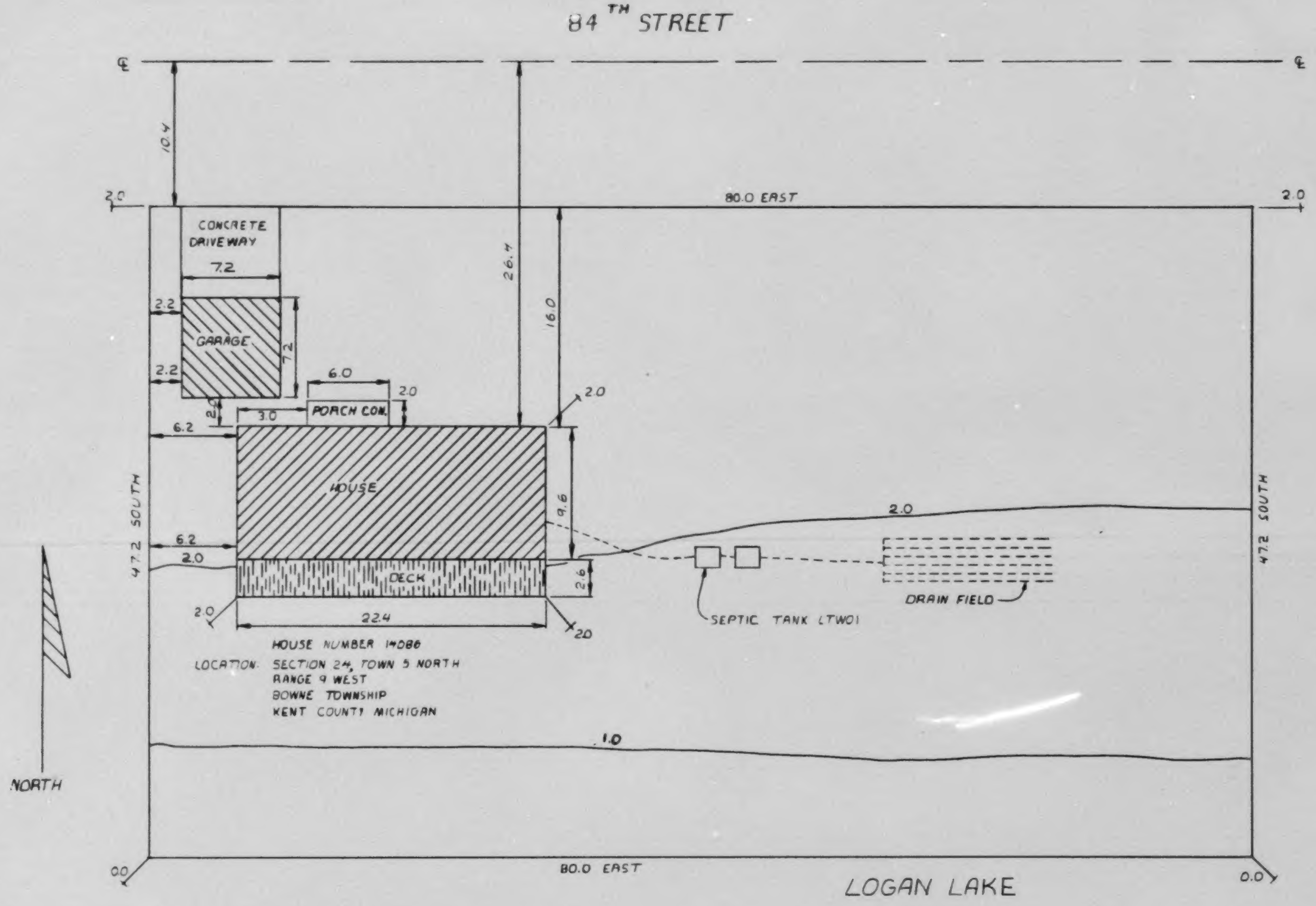
Total Points 20

1. State the following dimensions in millimetres from the drawing:
    - A. Length of garage _______
    - B. Length of overhead door _______
    - C. Distance from the structure to the west lot line _______
    - D. Elevation from lake level to grade line _______
    - E. Depth of footing from grade _______
    - F. Size of concrete slab--width _______ length _______
    - G. Thickness of concrete slab _______
    - H. Size of studs used in the walls: T _______, W _______, L _______
    - I. Total span _______
    - J. Total of roof structure _______
2. What form of framing does the roof have? _______
3. State the length in millimetres of the top cord for the roof structure. _______
4. State the distance between centers for wall studs. _______
5. What is the length of the driveway from the lot line to the garage in metres? _______
6. What is the thickness of the sand ballast under the concrete floor? _______
7. How much eave extension does the roof have? _______
8. State the thickness of the block splash wall. _______


7200
3200
2000
A
A
2900
A
4
2300
2300
FLOOR DRAINS
A
A
3200
7200
1
3500
3500
2
4
2000
1000
3600

DOOR	THK	TYPE	MANUFACTURE	CAT NO	QUAN
1 [475 , 2003]	[45]	FLUSH	CURTIS	C 1058	1
2 [5409 x 2135]	[35]	GARAGE	MC GEE	DRFT	1
WINDOW					
A [667 x 1029]		DBL HUNG	PELLA	2016 DH	5

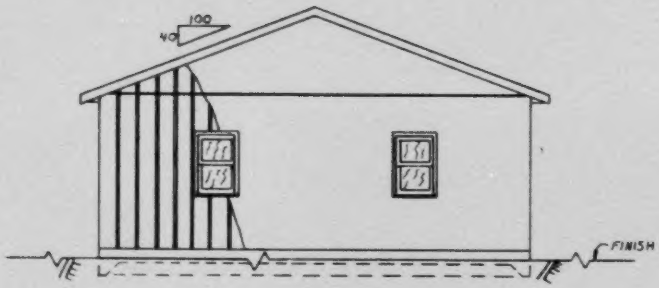
NOTE: -ALL DIMENSIONS IN MILLIMETRES
-ALL DIMENSIONS IN [ ] ARE DIRECT CONVERSION FROM INCHES TO MILLIMETRES


84TH STREET
℄
℄
10.4
26.4
16.0
2.0
80.0 EAST
2.0
CONCRETE DRIVEWAY
7.2
2.2
GARAGE
2.2
7.2
6.0
2.0
2.0
3.0
PORCH CON.
2.0
6.2
HOUSE
9.6
47.2 SOUTH
6.2
2.0
DECK
2.6
2.0
2.0
22.4
20
SEPTIC TANK (TWO)
DRAIN FIELD
47.2 SOUTH
HOUSE NUMBER 14086
LOCATION: SECTION 24, TOWN 5 NORTH
RANGE 9 WEST
BOWNE TOWNSHIP
KENT COUNTY MICHIGAN
1.0
NORTH
0.0
80.0 EAST
0.0
LOGAN LAKE

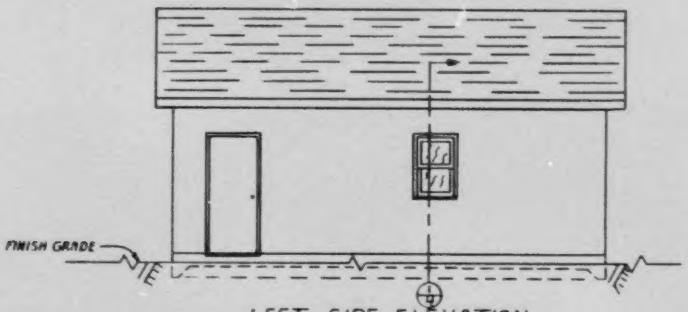
NOTE: – – – SEWER TILE
ALL DIMENSIONS IN METRES

PLOT PLAN

SCALE 1:200

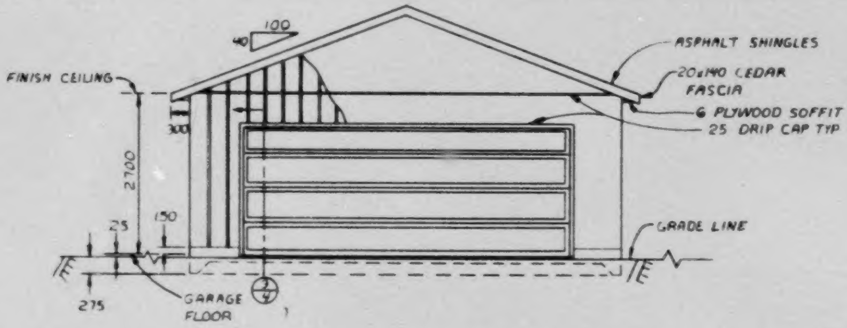

100
40
FINISH GRADE

REAR ELEVATION

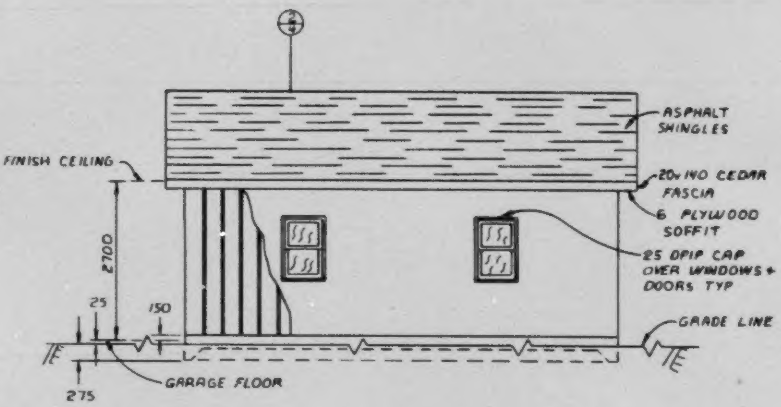

FINISH GRADE

LEFT SIDE ELEVATION

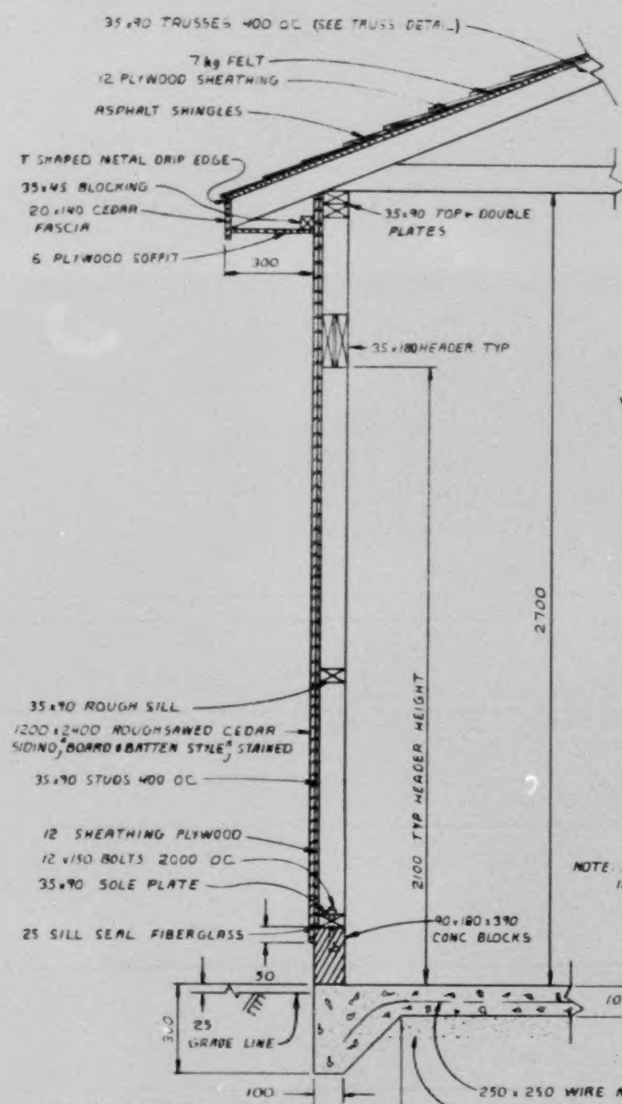
NOTE: ALL DIMENSIONS IN MILLIMETRES


100
40
ASPHALT SHINGLES
FINISH CEILING
20x140 CEDAR FASCIA
6 PLYWOOD SOFFIT
300
25 DRIP CAP TYP
2700
25
150
GRADE LINE
275
GARAGE FLOOR

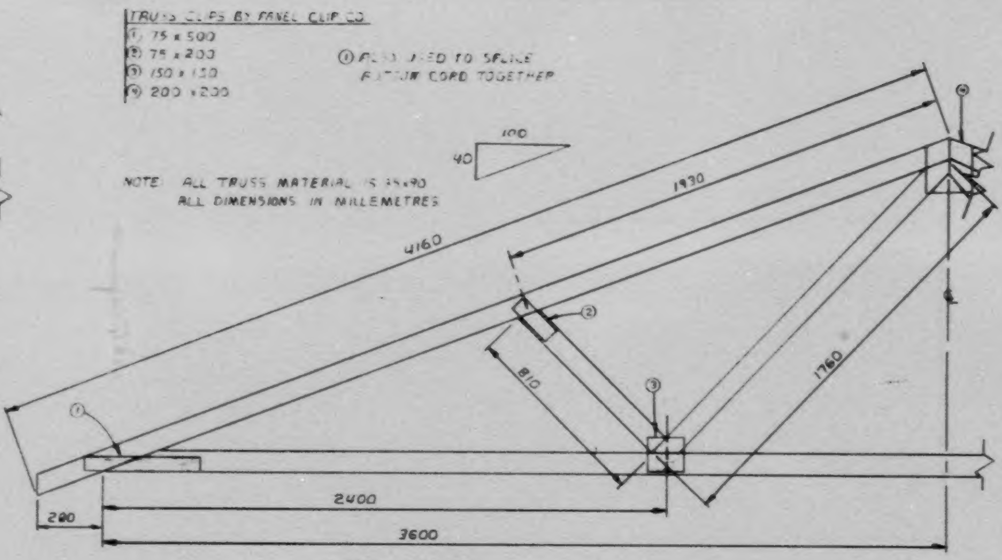
FRONT ELEVATION


ASPHALT SHINGLES
FINISH CEILING
20x140 CEDAR FASCIA
6 PLYWOOD SOFFIT
2700
25 DRIP CAP OVER WINDOWS + DOORS TYP
25
150
GRADE LINE
275
GARAGE FLOOR

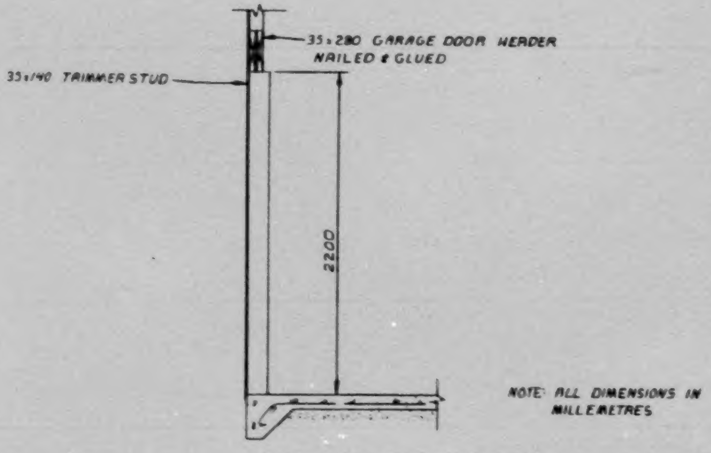
RIGHT SIDE ELEVATION


35 x 90 TRUSSES 400 OC (SEE TRUSS DETAIL)
7 kg FELT
12 PLYWOOD SHEATHING
ASPHALT SHINGLES
T SHAPED METAL DRIP EDGE
35 x 45 BLOCKING
20 x 140 CEDAR FASCIA
6 PLYWOOD SOFFIT
300
35 x 90 TOP + DOUBLE PLATES
35 x 180 HEADER TYP
2700
2100 TYP HEADER HEIGHT
35 x 90 ROUGH SILL
1200 x 2400 ROUGHSAWED CEDAR SIDING, "BOARD & BATTEN STYLE", STAINED
35 x 90 STUDS 400 OC
12 SHEATHING PLYWOOD
12 x 150 BOLTS 2000 OC
35 x 90 SOLE PLATE
25 SILL SEAL FIBERGLASS
90 x 180 x 390 CONC BLOCKS
50
25
GRADE LINE
300
100
300
100 CONC FLOOR
250 x 250 WIRE MESH
100 FILL SAND
NOTE ALL DIMENSIONS IN MILLEMETRES

① FOUNDATION & EXTERIOR WALLS
SCALE 1:10


TRUSS CLIPS BY PANEL CLIP CO
① 75 x 500
② 75 x 200
③ 150 x 150
④ 200 x 200
① [illegible] USED TO SPLICE BOTTOM CORD TOGETHER
100
40
NOTE: ALL TRUSS MATERIAL IS 35 x 90
ALL DIMENSIONS IN MILLEMETRES
4160
1930
810
1760
①
②
③
④
2400
280
3600

② TRUSS DETAIL
SCALE 1:1250


35 x 280 GARAGE DOOR HEADER NAILED & GLUED
35 x 140 TRIMMER STUD
2200
NOTE: ALL DIMENSIONS IN MILLEMETRES

③ GARAGE DOOR HEADER DETAIL SCALE 1:20

SUGGESTED LEARNING ACTIVITIES

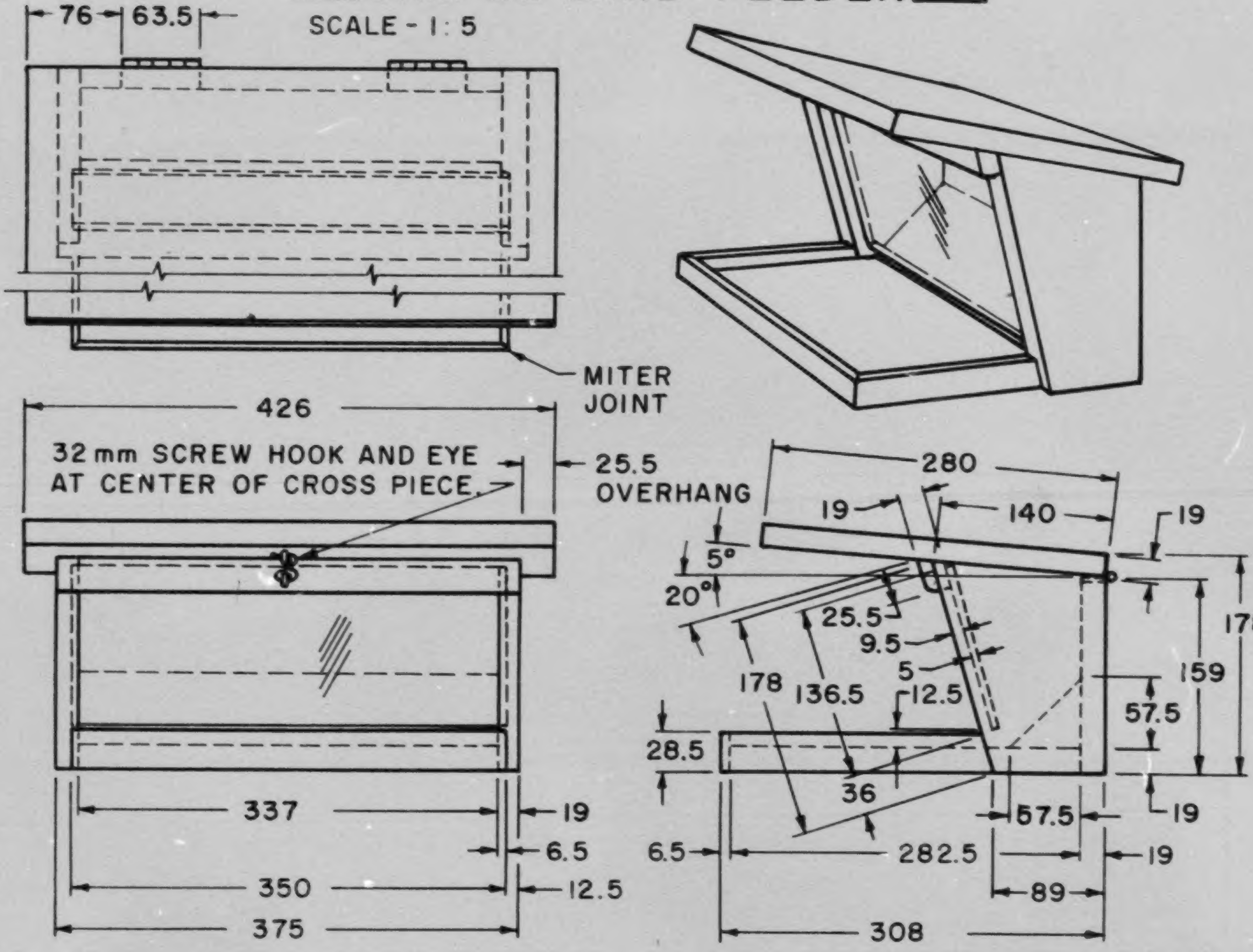
Plans Included

1. Simple Bird Feeder
2. Bird Feeder
3. Drafting Table
4. Work Bench
5. Child's Play House
6. Metric Garage (Pages 58 through 61)

Note: The garage plans provided in this unit are based on the 100 millimetre module. To expose students to actual construction type situations the structure may be constructed to a scale of 1:20.

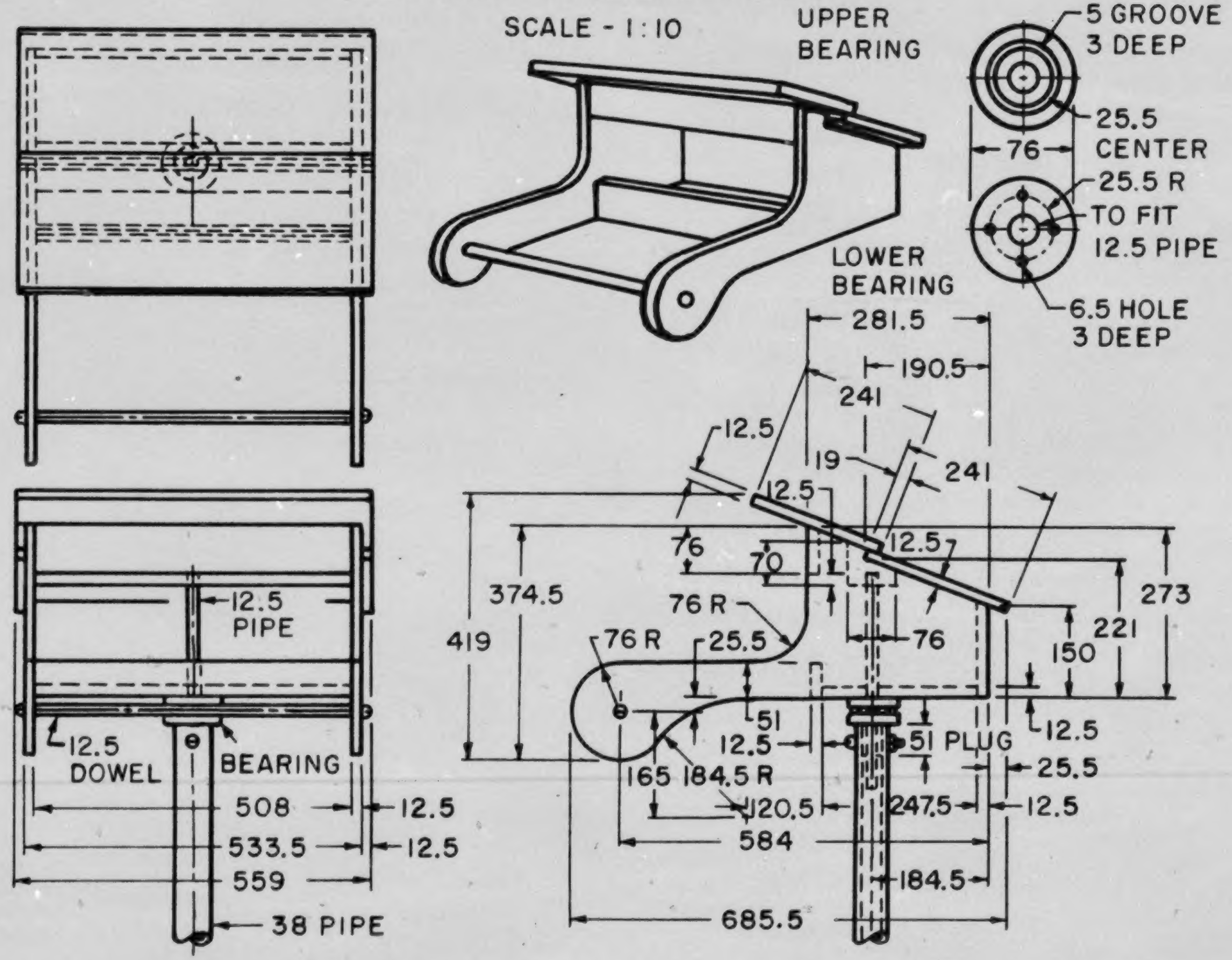
SIMPLE BIRD FEEDER

SCALE - 1:5

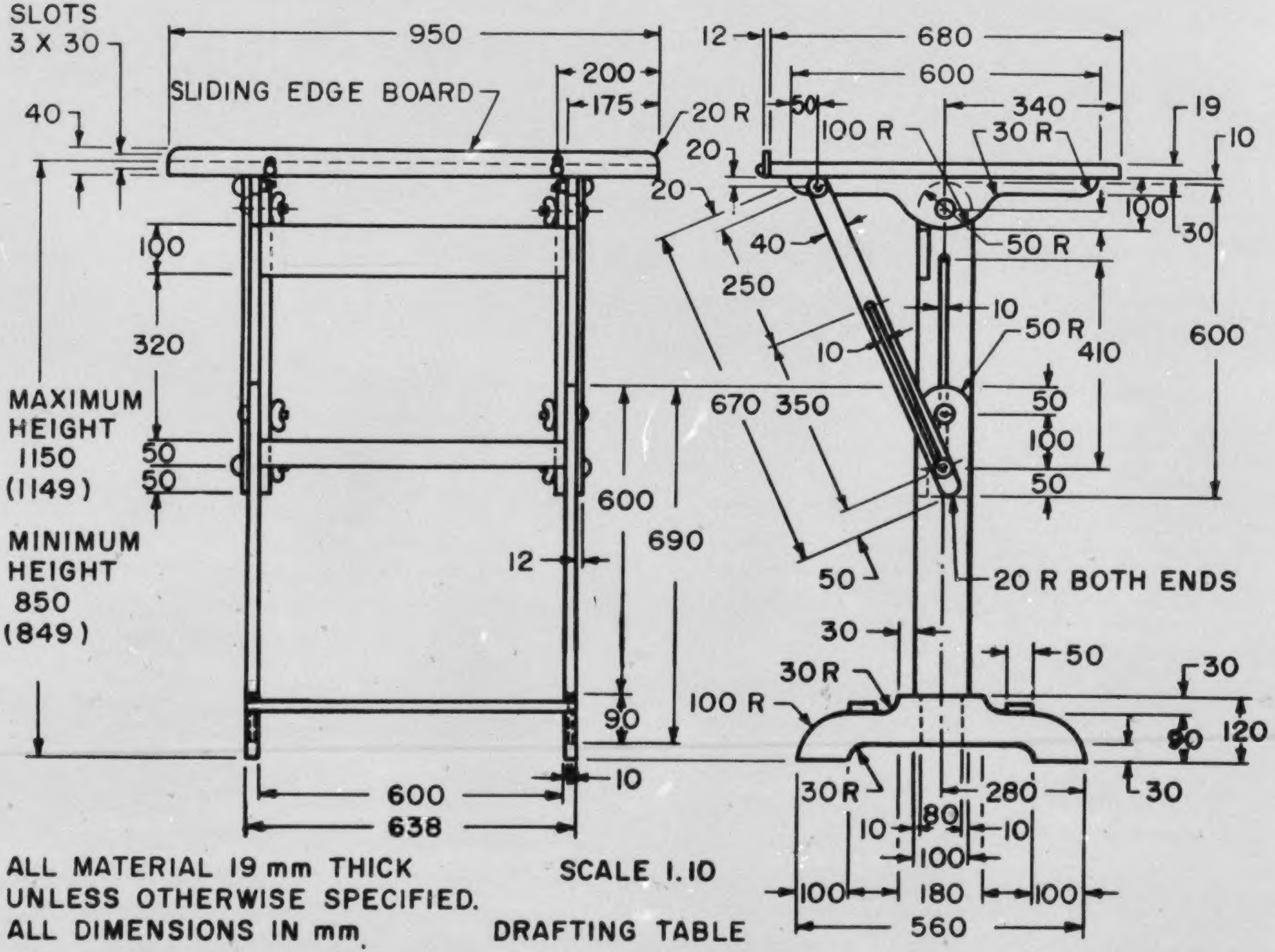

76
63.5
MITER JOINT
426
32 mm SCREW HOOK AND EYE AT CENTER OF CROSS PIECE.
25.5 OVERHANG
337
19
6.5
350
12.5
375
280
19
140
19
5°
20°
25.5
9.5
5
12.5
178
136.5
178
159
57.5
28.5
36
57.5
19
6.5
282.5
19
89
308

ALL DIMENSIONS IN mm

BIRD FEEDER



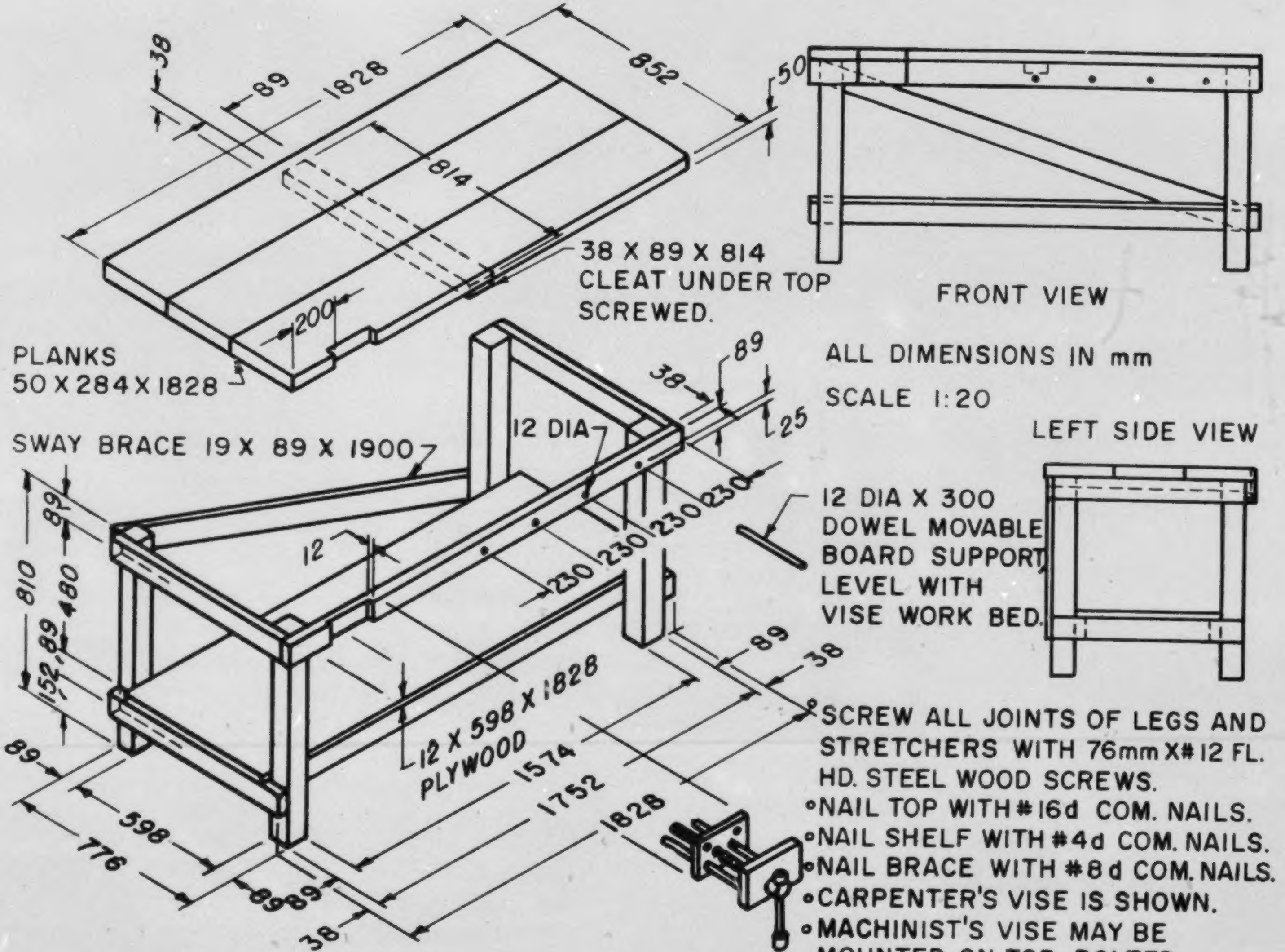
SCALE - 1:10
UPPER BEARING
5 GROOVE 3 DEEP
25.5 CENTER
76
25.5 R
TO FIT 12.5 PIPE
6.5 HOLE 3 DEEP
LOWER BEARING
281.5
190.5
241
12.5
19
241
12.5
12.5
76
70
374.5
76 R
419
76 R
25.5
76
273
221
150
51
12.5
51 PLUG
12.5
25.5
165
184.5 R
120.5
247.5
12.5
584
184.5
685.5
12.5 PIPE
12.5 DOWEL
BEARING
508
12.5
533.5
12.5
559
38 PIPE


SLOTS 3 X 30
950
200
175
SLIDING EDGE BOARD
40
20 R
100
320
MAXIMUM HEIGHT 1150 (1149)
50
50
MINIMUM HEIGHT 850 (849)
600
690
12
90
600
638
10
12
680
600
50
340
20
100 R
30 R
19
10
20
100
30
40
50 R
250
10
50 R
410
600
10
670 350
50
100
50
50
20 R BOTH ENDS
30
50
30 R
30
100 R
90
120
30 R
280
30
10
80
10
100
100
180
100
560

ALL MATERIAL 19 mm THICK
UNLESS OTHERWISE SPECIFIED.
ALL DIMENSIONS IN mm.

SCALE 1.10

DRAFTING TABLE


38
89
1828
852
50
814
38 X 89 X 814
CLEAT UNDER TOP
SCREWED.
200
PLANKS
50 X 284 X 1828
SWAY BRACE 19 X 89 X 1900
12 DIA
89
38
25
230
230
230
230
230
12
810
89
480
89
152
12 X 598 X 1828
PLYWOOD
12 DIA X 300
DOWEL MOVABLE
BOARD SUPPORT,
LEVEL WITH
VISE WORK BED.
89
38
1574
1752
1828
89
598
776
89
89
38

FRONT VIEW

LEFT SIDE VIEW

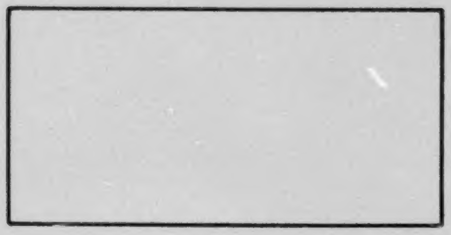
ALL DIMENSIONS IN mm

SCALE 1:20

- SCREW ALL JOINTS OF LEGS AND STRETCHERS WITH 76mm X# 12 FL. HD. STEEL WOOD SCREWS.
- NAIL TOP WITH #16d COM. NAILS.
- NAIL SHELF WITH #4d COM. NAILS.
- NAIL BRACE WITH #8d COM. NAILS.
- CARPENTER'S VISE IS SHOWN.
- MACHINIST'S VISE MAY BE MOUNTED ON TOP, BOLTED THROUGH TOP.

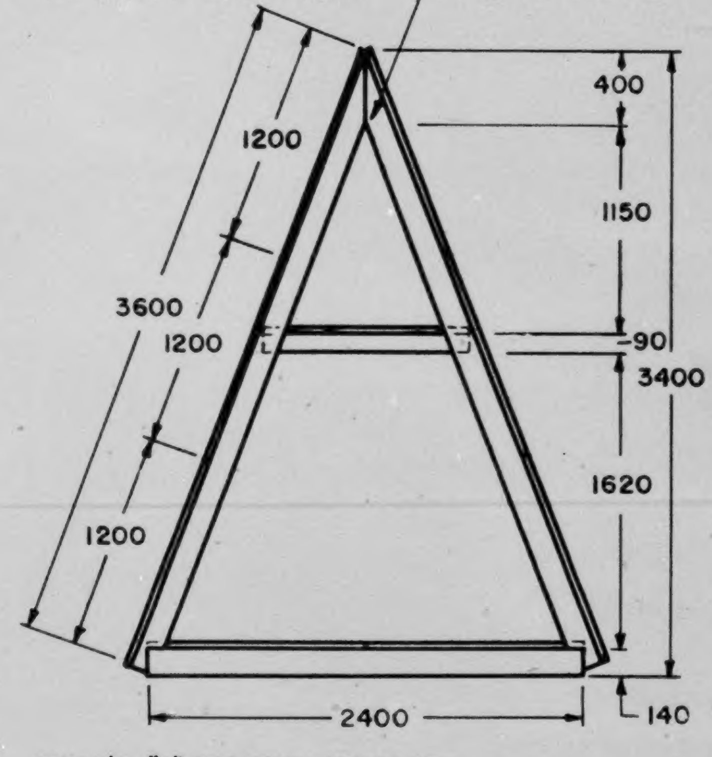
EXPLODED ISOMETRIC VIEW

WORK BENCH



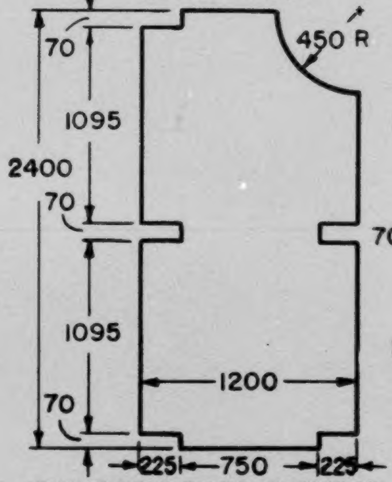
ROOF
12 X 1200 X 2400
PLYWOOD
6 PCS.

ALL DIMENSIONS IN mm


35 X 140 X 3600
3600
1200
1200
1200
400
1150
90
1620
3400
140
2400

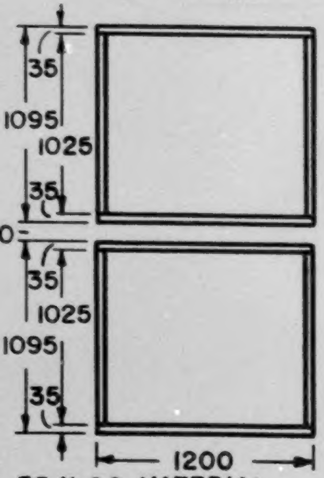
CHILD'S "A" FRAME PLAYHOUSE

UPPER DECK

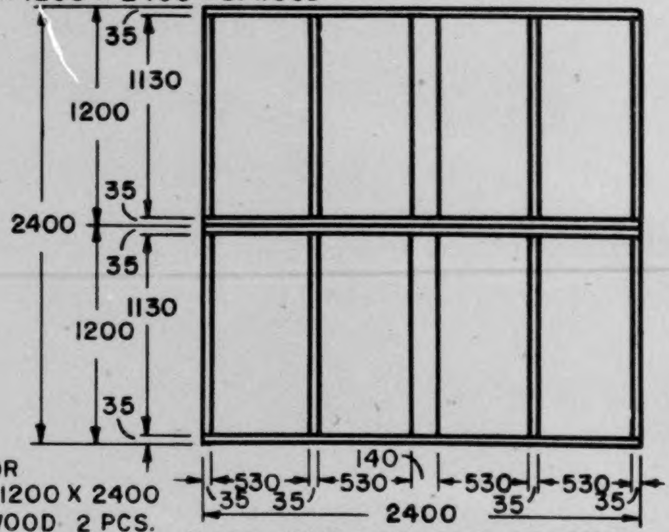

450 R
70
1095
2400
70
1095
70
1200
225
750
225

19 X 1200 X 2400 PLYWOOD

DECK FRAME


35
1095
1025
35
70
35
1025
1095
35
1200

35 X 90 MATERIAL


35
1130
1200
35
2400
35
1130
1200
35
140
530
530
530
530
35
35
35
35
2400

FLOOR
19 X 1200 X 2400
PLYWOOD 2 PCS.

FLOOR FRAME 35 X 140 MATERIAL

Section 2

Part G

TEACHING-LEARNING MODULE
METRICS IN MACHINE SHOP

INTRODUCTION

America is going metric at an ever increasing rate. This is particularly true in the area of manufacturing. Almost all multinational companies are beginning to design and manufacture their products in metric modules. Therefore, two of the first vocational areas that should be prepared in metrics are the draftsmen and the machinists. This teaching-learning module recommends the basic program that should be included in every total machine shop course. The amount of time available for metrics should be determined to some extent by the geographic location of the training program and by the level of student involvement.

CAREERS IN MACHINING OPERATIONS

Nearly every product made by American industry contains metal parts or is manufactured by machines made of metal parts. In 1972, about 1.1 million machinists, machine tool operators, tool and die makers, instrument makers and set-up men used a wide variety of machine and hand tools to shape these metal parts.

A machine tool is a stationary, power-drived device that holds and brings together the cutting instrument (tool) and the metal to be cut. Some of the most common machine tools are lathes and machines that drill, bore, mill, and grind. Metal can also be shaped by using chemicals, electricity, magnetism, sound, light, and liquids under controlled conditions.

Motors, farm machinery, and typewriters are among the wide variety of metal products with interchangeable parts that are mass-produced and easily assembled from drawings and blueprints. Precision instruments are frequently used to check the accuracy of metal parts that may be machined to tolerances of ten millionths of an inch.

All-round machinists can operate most types of machine tools, whereas machine tool operators generally work with only one kind. Tool and die makers make dies (metalforms) for presses and diecasting machines, devices to guide drills into metal, and special gages to determine whether the work meets specified tolerances. Instrument makers use machine tools to produce highly accurate instrument parts from metal and other materials. Set-up men adjust tools for semiskilled machine and tool operators to run.

Nature of the Work

The all-round machinist, who can set up and operate most types of machine tools, uses these tools to make metal parts. Because he plans and carries through all operations, he may switch from one product to another and give variety to his work. His knowledge of metals and machine tools enables him to turn a block of metal into an intricate part of precise specifications. He selects the tools and materials for each job and plans the cutting and finishing operations from a blueprint or written specifications. He makes standard shop computations relating to dimensions of work and machining specifications. He often uses precision-measuring instruments such as micrometers to measure the accuracy of his work to thousandths or even millionths of an inch. After completing machining operations, he may use hand files and scrapers before he assembles the finished parts with wrenches and screwdrivers.

Machinists who make and repair metal parts in maintenance departments must have a broad knowledge of the way machines work to adjust and test parts. In plants that produce large numbers of metal products, highly skilled machinists specialize in layout work and mark specifications on metal for machine tool operators who do the machining operations.

Places of Employment

An estimated 320,000 machinists were employed in 1972. Almost every factory using substantial amounts of machinery employed all-round machinists to maintain its mechanical equipment. Some all-round machinists made large quantities of identical parts in production departments of metalworking factories; others made limited numbers of varied products in machine shops. Most all-round machinists worked in the following industries: machinery, including electrical; transportation equipment; fabricated metal products; and primary metals. Other industries employing substantial numbers of these workers were the railroad, chemical, food processing, and textile industries. The Federal Government also employed all-round machinists in Navy yards and other installations.

Machinists have great flexibility in their work because all types of machinery in nearly every locality require their skills.

Training, Other Qualifications and Advancement

A four-year apprenticeship is the usual way to learn the machinist trade, but some companies have training programs for single purpose machines that require less than four years. Many machinists, however, learn on the job.

A young person interested in becoming a machinist should be mechanically inclined and temperamentally suited to do highly accurate work that requires concentration as well as physical effort. A prospective machinist should be able to work independently. Although the work is sometimes tedious and repetitious, the all-round machinist frequently has the satisfaction of seeing the final results of his work.

A high school or vocational school education, including mathematics, physics, or machine shop training, is desirable. Some companies require experienced machinists to take additional courses in mathematics and electronics at company expense so that they can service and operate numerically controlled machine tools. In addition, equipment builders generally provide training in the electrical, hydraulic, and mechanical aspects of machine-and-control systems.

A typical machinist apprentice program lasts four years and consists of approximately eight thousand hours of shop training and about five hundred seventy hours of related classroom instruction. In shop training, the apprentice learns chipping, filing, hand tapping, dowel fitting, riveting, and the operation of various machine tools. In the classroom he studies blueprint reading, mechanical drawing, shop mathematics and shop practices.

All-round machinists have numerous opportunities. Many advance to foreman or supervisory jobs. Some take additional training and become tool and die or instrument makers. A skilled machinist may open his own shop or advance into other technical jobs in machine programming and tooling.

Employment Outlook

The number of all-round machinists is expected to increase moderately through the mid-1970's as a result of the anticipated expansion of metalworking activities. Most job openings will arise from the need to replace experienced machinists who retire, die, or transfer to other fields of work.

The demand for machinists will be affected by two main factors. As population and income rise, so will the demand for machined goods, such as automobiles, household appliances, and industrial products. Partially offsetting this, however, will be worker-productivity increases resulting from technological developments.

Chief among these technological innovations is the expanding use of numerically-controlled machine tools. These machines, which translate numbers into a series of motions and processes, significantly reduce the time required to perform machining operations.

Much of the employment growth will occur in maintenance shops, as industries continue to use a greater volume of complex machinery and equipment. Skilled maintenance machinists are needed to prevent costly breakdowns in highly mechanized plants. In such plants, a breakdown of one machine may stop many other machines.

Earnings and Working Conditions

The earnings of machinists compare favorably with those of other skilled workers. Machinists must follow strict safety regulations when working around high-speed machine tools. Short-sleeve shirts, safety glasses, and other protective devices are required to reduce accidents. Most shops are clean and workplaces are well-lighted.

Companies employing machinists generally provide paid vacations and holidays. Other fringe benefits frequently included health and life insurance, accident insurance, supplemental unemployment benefits, and pensions.

Many machinists are members of unions including the International Association of Machinists and Aerospace Workers; the International Union, United Automobile, Aerospace, and Agricultural Implement Workers of America; the International Union of Electrical, Radio and Machine

Workers; the United Steelworkers of America; and the Mechanics Educational Society of America.

METRIC IMPLICATIONS

1. Machine Tools Today. The Five Basic Machines
    - A. Metric competencies
        1. dual reading dials
        2. digital readout units
        3. mechanical metric scales
2. Metal Cutting and Cutting Fluids
    - A. Liquid volume in litres and millilitres
3. Mechanics of Machines
    - A. Speeds and feeds in metric units
    - B. Metric gears
    - C. Metric tapers
    - D. Metric limits, tolerances and fits
4. Safety in the Machine Shop
5. Using Metric Mathematics
    - A. Division of decimals
    - B. Addition of decimals
    - C. Decimal equivalents
    - D. Subtraction of decimals
    - E. Reading and writing decimals
    - F. Rounding off decimals
    - G. Calculating size of geometric figures
6. Selecting Metals
    - A. Metric standards
    - B. Metric thicknesses, widths and lengths
7. Reading a Drawing and Planning Your Work
    - A. Metric limits
    - B. Metric tolerances
    - C. Metric drafting practices
    - D. Reading a metric rule
    - E. Dual dimensioning
    - F. Metric measurement with chart method
    - G. All metric drawing
    - H. Standards for surface roughness in metrics
8. Cutting Off Stock to Length with Power Saws
    - A. Determining metric lengths
    - B. Number of teeth per 25 millimetres
9. Principles of Measurement
    - A. The metric system
    - B. Prefixes
    - C. Base, supplementary and derived units
    - D. Common derived units used in machine shop--square metre, cubic metre, newton, pascal, joule and watt

10. Basic Measuring Tools
    A. Reading a metric rule
    B. Using a metric combination square
11. Using Calipers
12. Reading and Using a Metric Micrometer
    A. Standard metric micrometer and how to read
    B. Reading a quick reading metric micrometer
13. Using a Metric Vernier Caliper
14. Reading a Metric Dial Indicator
15. Using Metric Gage Blocks and Other Metric Measuring Tools
16. The Sine Bar and Angle Gage Blocks
    A. Figuring angles
    B. Using metric dimensions
17. Making a Layout in Metric
18. Cutting with a Hacksaw
    A. Teeth per 25 millimetres
19. Cutting with a Cold Chisel
20. Filing, Broaching and Scraping
    A. File lengths in millimetres
    B. Broaches to metric dimensions
21. Sizes of Abrasive Materials in Metric
22. Using a Bench and Power Grinder
    A. Sizes of grinding wheels in metric
23. Screw Threads and Thread Measuring
    A. ISO inch threads
    B. ISO metric threads
24. Cutting Screw Threads with Taps and Dies
    A. Selecting the correct tap drill for metric taps
25. Reaming at the Bench
    A. Metric reamers
26. Metal Fasteners and Tools for Assembly
    A. Metric fasteners
    B. Metric wrenches
    C. Metric torque wrenches in newton metres
27. Safe Use of Hand Tools
28. Band Machining Equipment
    A. Measurements given in metric
    B. Minimum radius given in metric
    C. Sizes of wheels given in metric
    D. Number of teeth per 25 millimetres
    E. Length of blade in metric
29. Band Machining
    A. Speeds for band sawing in millimetres per minute
30. Sizes of Drill Presses in Metric
    A. Depth gage in metric
    B. Cutting speeds in metric
    C. Feeds in metric
31. Metric Twist Drills--Standard Sizes
32. Drilling Holes in Flat Metal
    A. Laying out in metric
    B. Using metric drills

33. Laying Out and Drilling in Metric
34. Selecting Correct Metric Size Reamers
35. Using Metric Countersink and Counter Boring Tools
36. Drilling Machines in Industry
37. The Engine Lathe
    A. Sizes in metric
    B. Dual reading dials
    C. Metric gear box
    D. Power in kilowatts
    E. Energy in kilojoules
    F. Pressure in kilopascals
    G. Force in kilonewtons
38. Learning to Use Dual Reading Dials
39. Care of Lathes and Personal Safety
40. Metric Cutting Tools in Metric Sizes
41. Speeds, Feeds and Depths of Cuts in Metric Standards
42. Making Layouts Using Metric Rules
43. Placing the End of the Workpiece Held Between Centers
44. Rough Turning Between Centers
45. Using Dual Reading Dial
46. Using Metric Radius Gage
47. Installing a Chuck and Machining the Workpiece
48. Facing, Turning and Cutting Off a Workpiece Mounted in a Chuck
49. Using Metric Size Drills
50. Boring to Metric Dimensions and Checking size of Hole Using Metric Measuring Tools
51. Reaming to Metric Dimensions
52. Sizes of Mandrels in Metric
53. Mounting a Workpiece in the Collet Chuck or on a Faceplate
54. Knurling
55. Filing and Polishing
56. Figuring Tapers in Metric
57. Adjusting Tapers in Decimal Degrees
58. Taper Turning and Cutting Angles with the Compound Rest
59. Turning and Boring with a Steady or Follower Rest
60. Grinding Cutting Tool for Metric Threads
61. Adjusting Gear Box for Cutting Metric Threads
62. Using a Metric Thread Chasing Dial
63. Cutting Metric Threads
64. Turret (Indexing) Lathes
65. Lathes in Industry
66. Replacing Measuring Units in Metric
67. Cutting Speeds in Metric
68. Cutting Tools in Metric
69. Work-Holding Devices
70. Machining a Horizontal Surface
71. Making a Vertical Cut
72. Other Shaping Processes

73. Shapers and Planers in Industry
74. Metric Dimensions for Milling Machines
75. Metric Milling Machine Cutters
76. Speeds, Feeds in Metric--Millimetres per Minute (mm/min)
77. Work-Holding Devices and Their Uses
78. Milling a Flat Surface (Plain or Slab Milling)
79. Set-Ups in Metric
80. Using Dual Reading Dials or Digital Readout Units
81. Cutting a Metric Gear
82. Metric Speeds and Feeds
83. Adjusting to Metric Measurements
84. Milling Machines in Industry
85. Sizes of Machines in Metric
86. Sizes of Grinding Wheels in Metric
87. Finish Measured in Micrometres (µm)
88. Heats in Degrees Celsius
89. Hardening Temperatures in Degrees Celsius
90. Tempering Colors in Degrees Celsius
91. Testing to Metric Standards
    A. Weight in kilograms and grams
    B. Pressure in kilopascals
92. Numerical Control Changing Metric Dimensions to Customary for Numerical Control

PERFORMANCE OBJECTIVES

1. The machinist will:
    A. learn that the metre is equal to 1000 millimeters
    B. learn the meaning of and use of the symbol mm
    C. realize that measuring with a full millimetre is more precise than 1/16th of an inch and less precise than 1/32nd of an inch
    D. given a 300 mm rule divided into millimetres, the machinists will be able to measure to the closest millimetre (1 mm)
    E. with the rule the machinist will be able to make careful measurements and to read the graduations in millimetres
    F. measure lengths to the nearest millimetre
    G. given a rule marked in half millimetres, the machinist will realize that measuring with half millimetres is more precise than 1/32nd of an inch and less precise than 1/64th
    H. lay out measurement lengths to the half millimetre (0.5 mm)
    I. be able to read measurements to the half millimetre (0.5 mm)

J. when given a standard metric micrometer and workpieces, measure the workpieces with the micrometer to hundredths of a millimetre (0.01 mm)
K. understand the parts of the micrometer
L. understand that the pitch of the micrometer screw thread is 0.5 mm
M. understand that the smallest division on the thimble is 0.01 millimetre
N. given a direct reading standard micrometer, he will understand that:
    1. the pitch of the thread is 1 millimetre (1 mm)
    2. that every complete turn of the thimble equals 1 millimetre
    3. that the smallest division on the thimble is 0.01 millimetre
O. given a direct reading standard micrometer and a set of workpieces, he will read accurately to 0.01 millimetre
P. given a metric vernier caliper, he will:
    1. understand that there are several different types of verniers and each is read differently
    2. be able to determine differences between each of the vernier calipers
    3. check the main scale and the vernier scale to see how millimetres are divided into smaller divisions
    4. given a vernier and workpieces, the machinist will be able to read to the accuracy available on the vernier scale
Q. given other metric measuring tools, he will:
    1. be able to select the blade necessary to secure the proper metric thickness
    2. be able to select the proper radius gage to check metric radius
R. given a set of metric gage blocks, the machinist will be able to:
    1. select the necessary gage blocks to make the necessary thickness
    2. assemble the gage blocks into a single unit
    3. use the gage blocks to check micrometers, verniers and other precision measuring tools.

2. The machinist will be able to:
    A. understand the comparison between the metric and customary measurements on the dual reading dials
    B. adjust the depth of cut to the desired amount in hundredths of a millimetre
    C. convert metric to customary dimensions.

3. Given a milling machine with a digital readout unit, the machinist will:
   A. be able to turn on the machine
   B. be able to set the X and Y axes to 0
   C. be able to move the X and Y axes to the desired amount following the readout on the digital readout units
   D. be able to change from customary to metric measurement by flipping the switch and understanding the comparison between the two measurements.
4. The machinist will:
   A. realize that liquids are measured in litres and millilitres
   B. learn the meaning and correct use of the symbol ℓ or l for litres
   C. determine the amount of oil needed by machines in litres or millilitres.
5. The machinest will:
   A. understand the concept of weight/mass in the metric system
   B. realize that the kilogram is the unit of mass or weight
   C. know the meaning of and symbol kg
   D. measure weights in grams and kilograms.
6. The machinist will understand:
   A. the concept of derived units in metrics
   B. that forces are given in newtons - N
   C. that pressures are given in pascals - PA
   D. and be able to figure pressures in kilopascals
   E. and know that energy and work is given in joules - J
   F. and know how to figure energy and work problems involved in metrics in kilojoules - kJ
   G. and know that power is given in watts - W
   H. and know how to figure the power of machines in kilowatts - kW.
7. The machinist will:
   A. be able to compare the advantages and disadvantages of the metric system
   B. be able to give the seven base SI units and indicate their symbols
   C. be able to give the supplementary units and tell why they are not commonly used
   D. recognize the derived units of metric measurement
   E. be able to list the common prefixes for all base metric units
   F. measure and express resulting measurements using 300 mm rule to an accuracy of plus or minus 0.5 mm
   G. be able to convert metric units of measurement to customary units and vice versa

H. describe a metric dial indicator and be able to read to the graduations indicated.

8. The machinist will:
    - A. be able to read an all metric drawing
    - B. be able to make a metric sketch
    - C. be able to convert a customary drawing to metric
    - D. be able to read a metric drawing with a customary readout chart.

COURSE OUTLINE IN MACHINE SHOP

COURSE OUTLINE	AUDIO-VISUALS	ACTIVITIES & ASSIGNMENTS
1-History of Measurement	FS-Introduction to SI	Pre-test - Metric You
2-Basic SI Metrics		Self Study Book A (Introduction to the Modernized Metric System)
3-Technical SI Metrics		
4-Length	TM-Length	Self Study Book 1 (Length)
5-Area	TM-Area	Self Study Book 2 (Area)
6-Volume and Capacity	TM-Volume and Capacity	Self Study Book 3 (Vol. and Capacity
7-Mass and Weight	TM-Mass and Weight	Self Study Book 4 (Mass and Temperature)
8-Temperature	TM-Temperature	
9-Other Base Units and Supplementary Units	TM-Derived Units	
10-Derived Units	FS-Derived Units	
11-Rules When Using SI Units	TM-Rules	
12-Conversion Methods and Techniques		
13-Historical Persons in SI Metric	Pictures of Scientists	
14-Precision Metric Rules	FS-Reading a Metric Rule	Self Study Book B (Rules)
15-Metric Micrometers	TM-Micrometer FS-Micrometer	Self Study Book D (Micrometer)
16-Vernier Calipers, Height-Depth Gage	FS-Vernier Caliper	Self Study Book C (Vernier Caliper)

FS - filmstrip
TM - transparency

COURSE OUTLINE IN MACHINE SHOP Continued

COURSE OUTLINE	AUDIO-VISUALS	ACTIVITIES & ASSIGNMENTS
17-Other Precision Measuring Instruments		Self Study Book E (Other Precision Measuring Instruments)
18-National and International Standards	FS-Threads TM-Threads	
19-Paper Standards		
20-Thread Standards		
21-Other Engineering Standards		
22-Metrics in the Design Stage	FS-Geometric Dimensioning and Tolerancing	
23-Drafting Equipment and Supplies	TM-Going Metric in Drafting	Self Study Book F (Drafting Scales)
24-Drafting Methods and Standards		Self Study Book G (Drawings)
25-Beginning Drafting Practices		
26-Conversion of Metric Tools		
27-Metric Machining	TM-Going Metric in Metalworking	
28-Cutting Metric Threads		
29-Threaded Fasteners		
30-Wrenches		Post Test

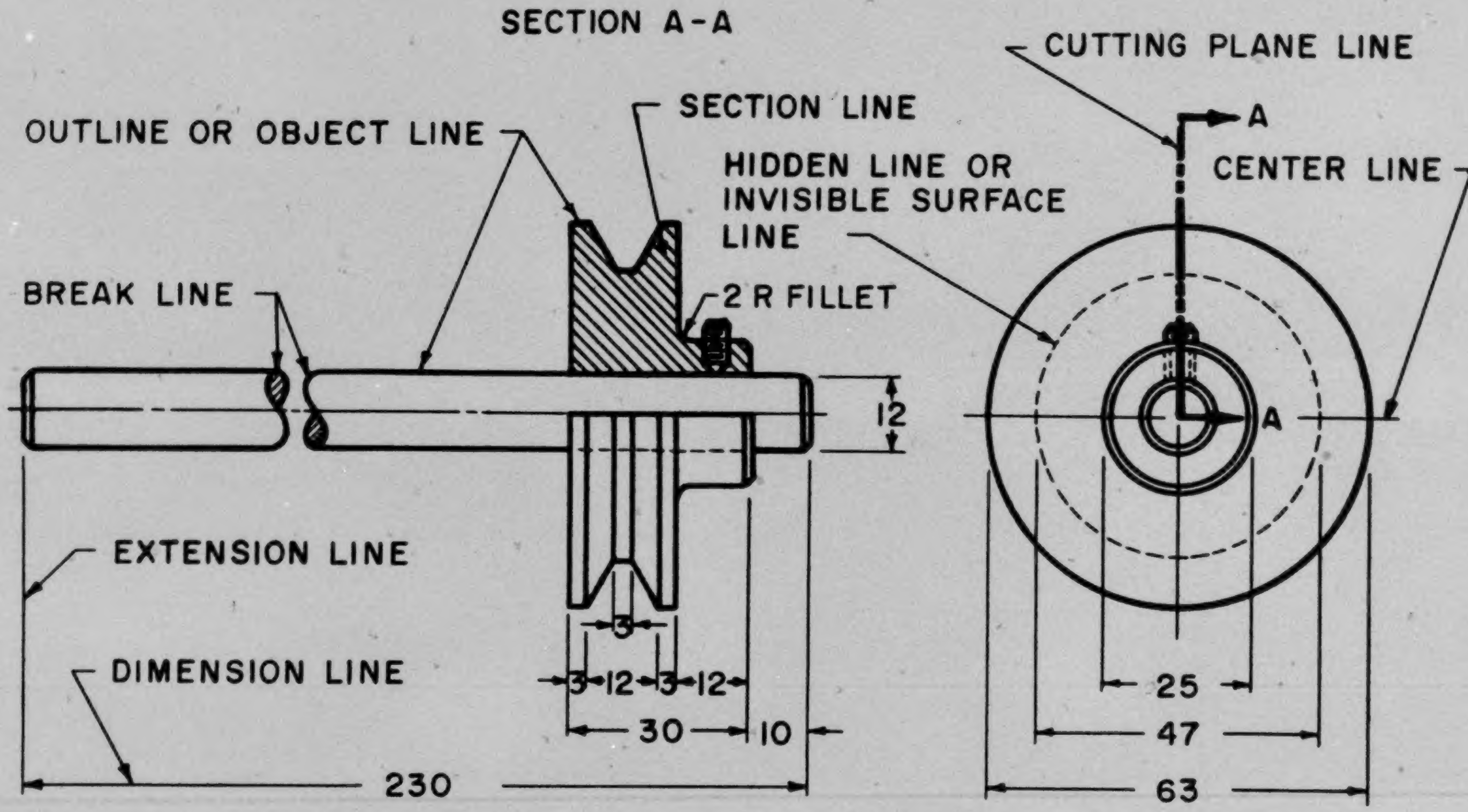
FS - filmstrip
TM - transparency

LEARNING ACTIVITIES

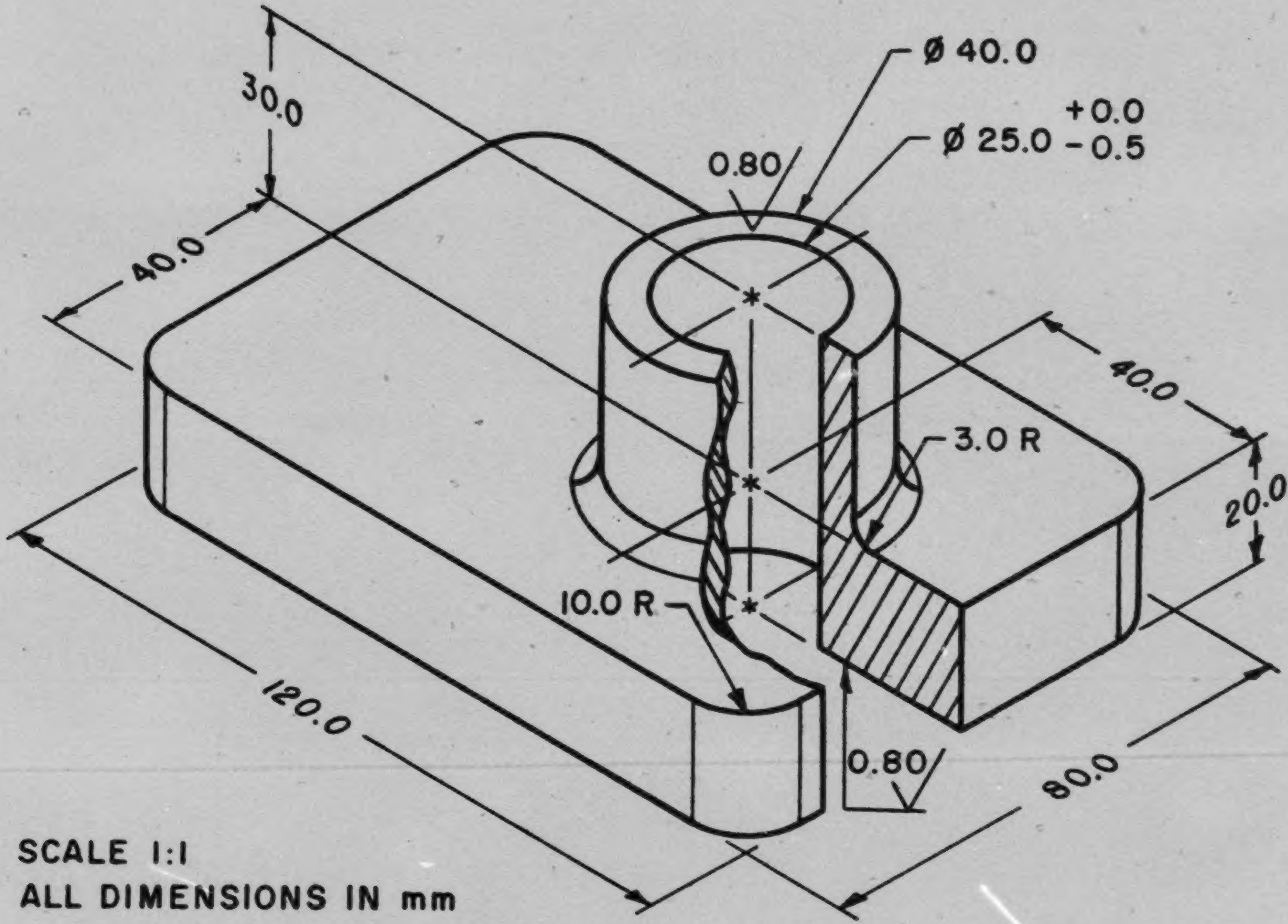
The following are suggested learning activities in machine shop:

1. Print reading - pulley
2. Print reading - flange
3. Print reading - mandrel
4. Print reading - V-block
5. Print reading - scriber
6. Print reading - screw driver
7. Print reading - bending block
8. Print reading - small anvil
9. Print reading - cast bookends
10. Print reading - cast paperweight
11. Print reading - sine bar

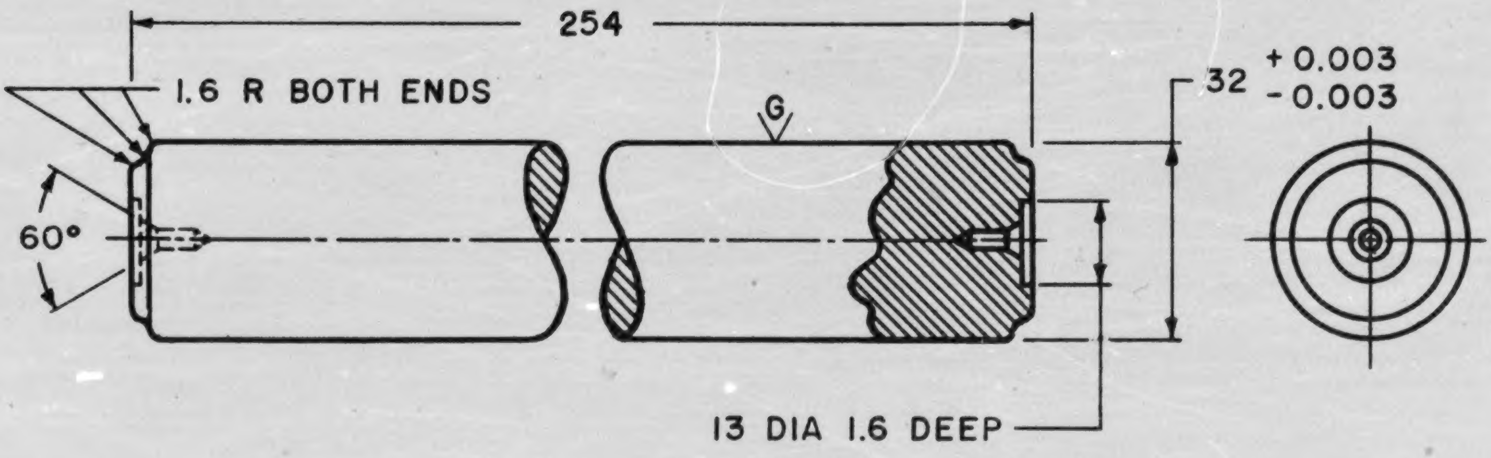
Any of the above drawings can be used by the student to make a project in metric only.


SECTION A-A
CUTTING PLANE LINE
SECTION LINE
OUTLINE OR OBJECT LINE
HIDDEN LINE OR INVISIBLE SURFACE LINE
CENTER LINE
A
A
BREAK LINE
2 R FILLET
12
EXTENSION LINE
DIMENSION LINE
3
3
12
3
12
30
10
230
25
47
63

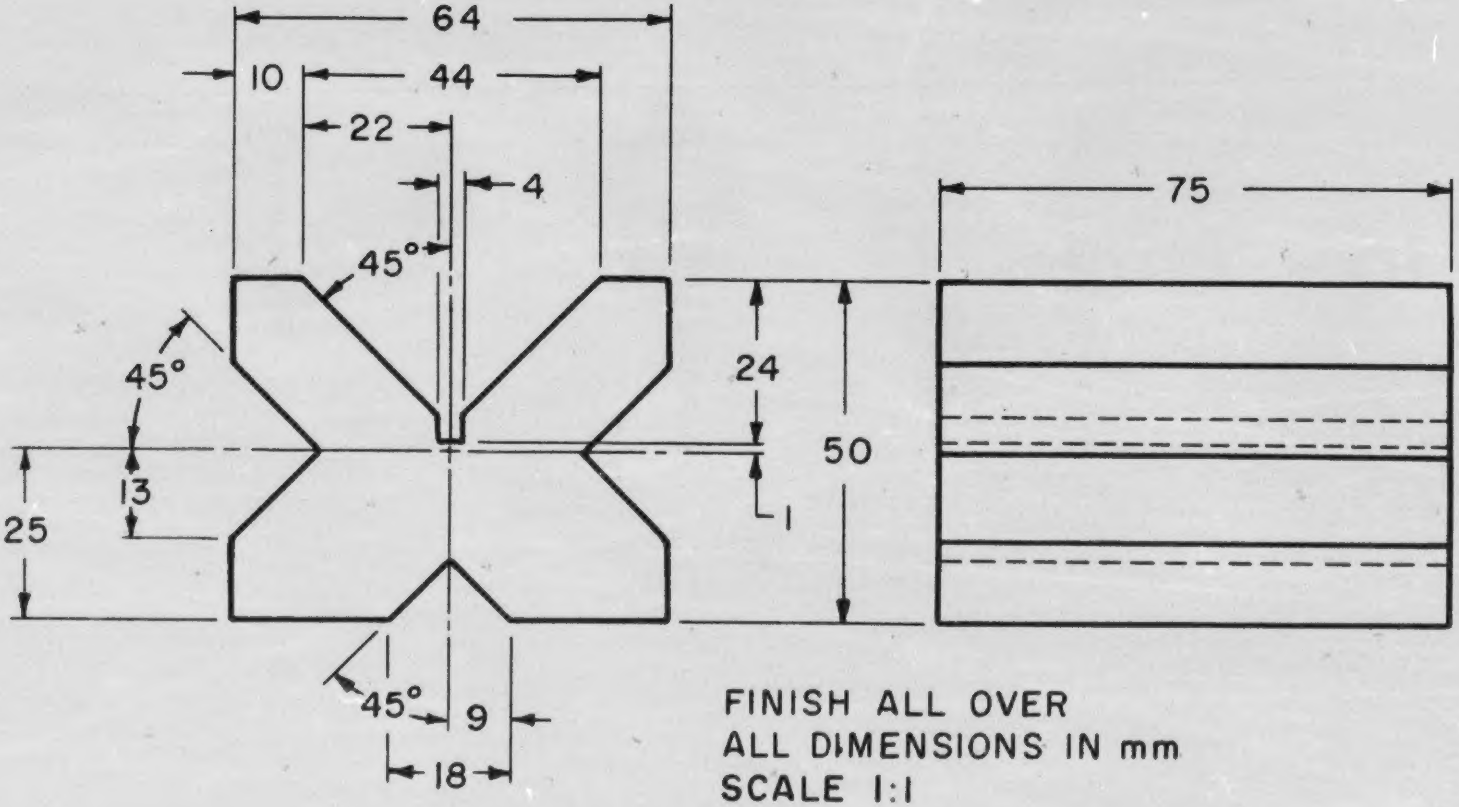
SCALE 1:1
ALL DIMENSIONS IN mm


Ø 40.0
+0.0
Ø 25.0 -0.5
0.80
30.0
40.0
40.0
3.0 R
20.0
10.0 R
120.0
0.80
80.0

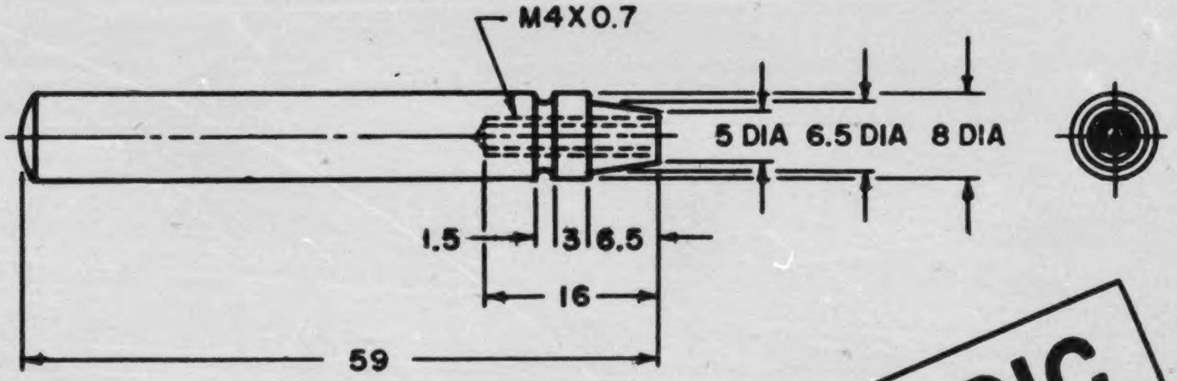
SCALE 1:1
ALL DIMENSIONS IN mm


254
1.6 R BOTH ENDS
G
32 +0.003 -0.003
60°
13 DIA 1.6 DEEP

ALLOW 0.30 TO 0.40 FOR GRINDING
SCALE 1:1
ALL DIMENSIONS IN mm

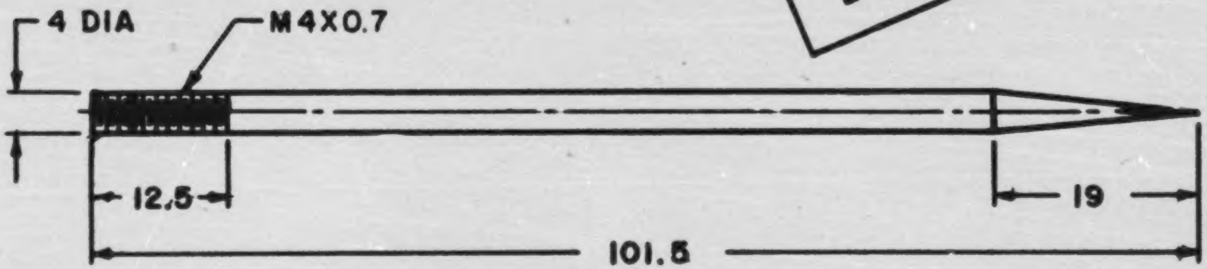

64
10
44
22
4
45°
75
45°
24
50
13
25
1
45°
9
18

FINISH ALL OVER
ALL DIMENSIONS IN mm
SCALE 1:1


M4X0.7
5 DIA
6.5 DIA
8 DIA
1.5
3
6.5
16
59

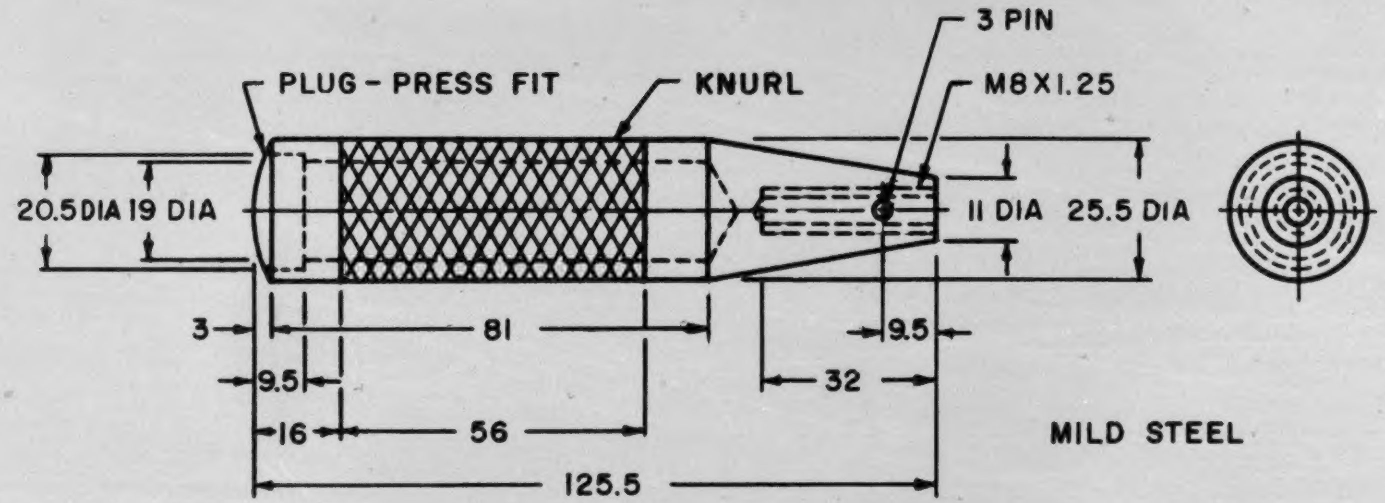
HANDLE

METRIC


4 DIA
M4X0.7
12.5
19
101.5

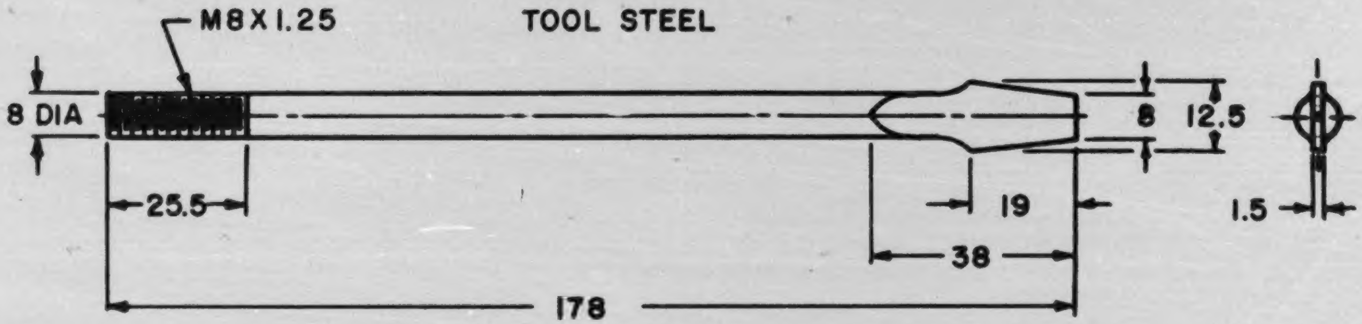
POINT

SCRIBER


3 PIN
PLUG - PRESS FIT
KNURL
M8X1.25
20.5 DIA
19 DIA
11 DIA
25.5 DIA
3
81
9.5
9.5
32
16
56
125.5

MILD STEEL

HANDLE

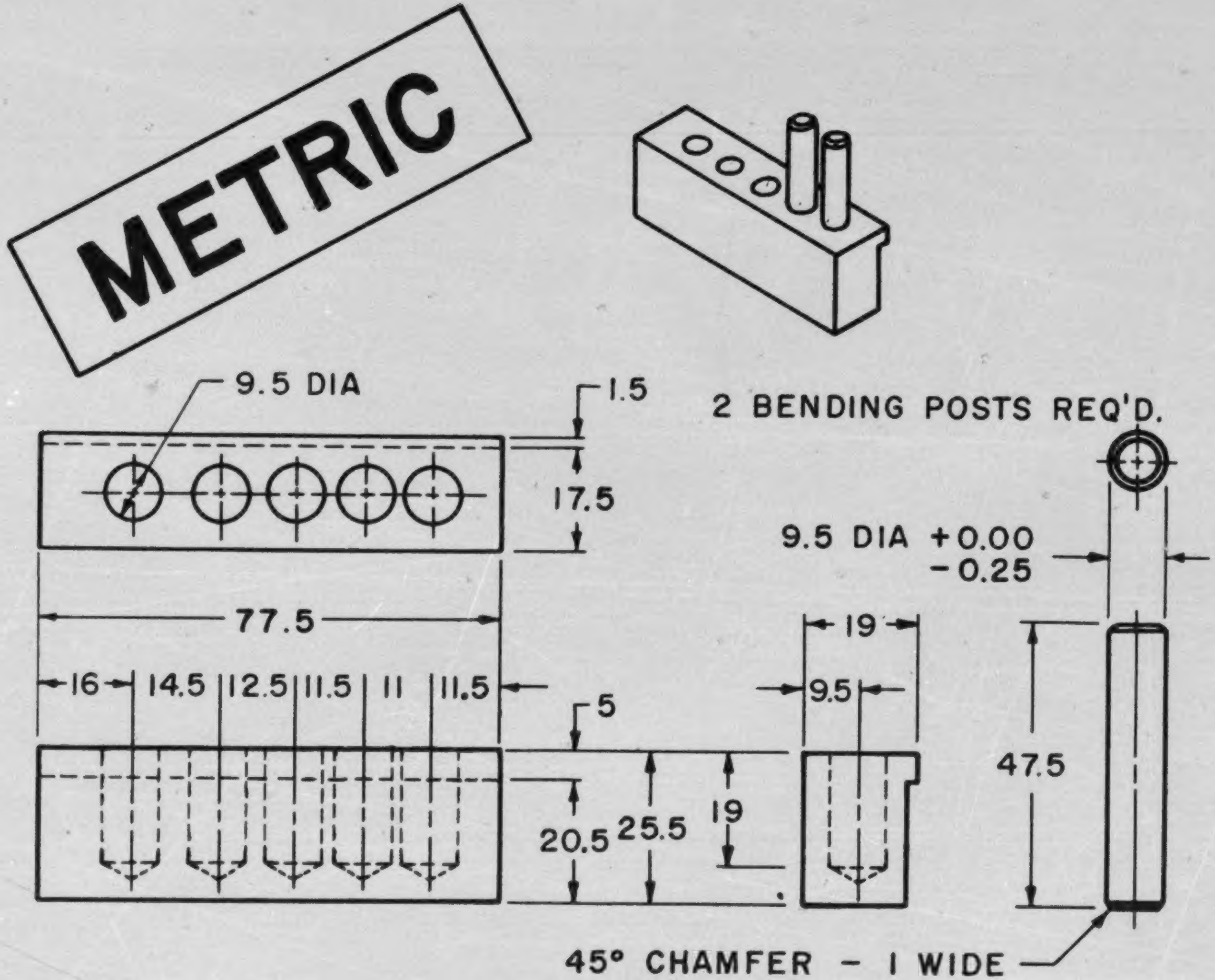

M8X1.25
8 DIA
8
12.5
25.5
19
1.5
38
178

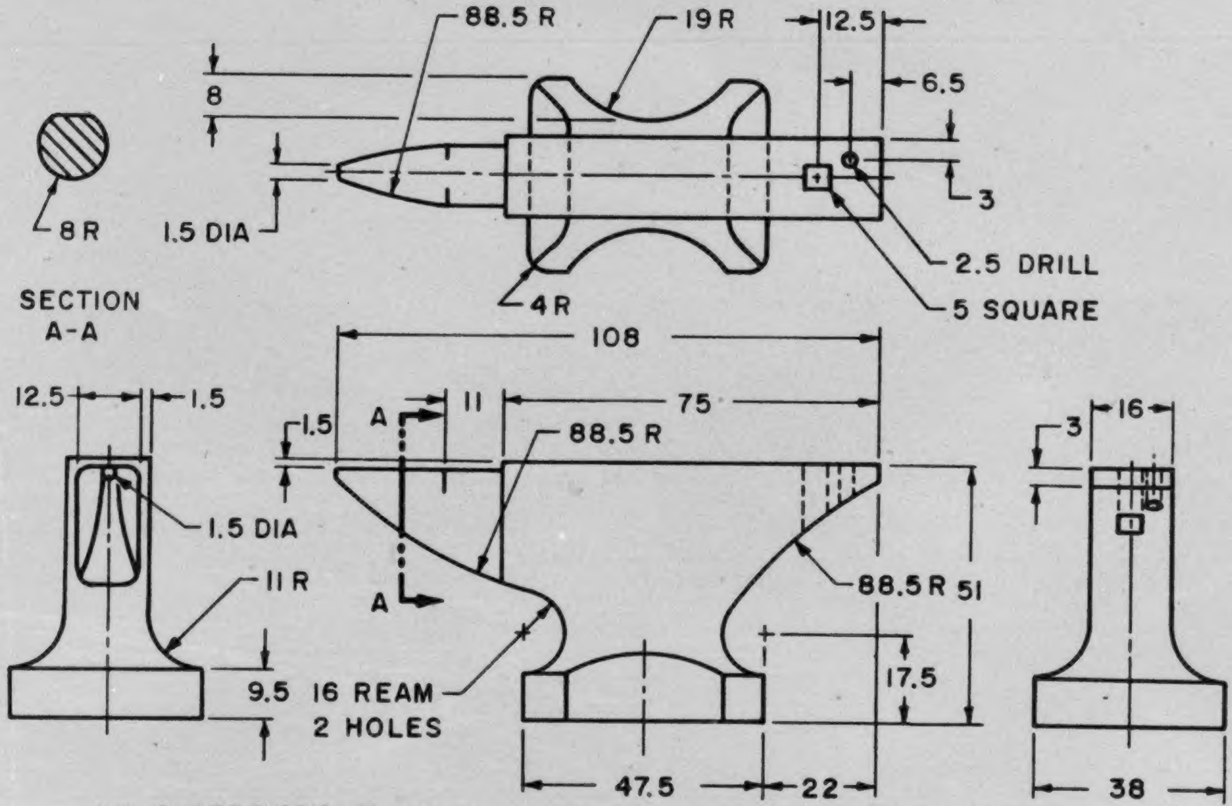
TOOL STEEL

BLADE

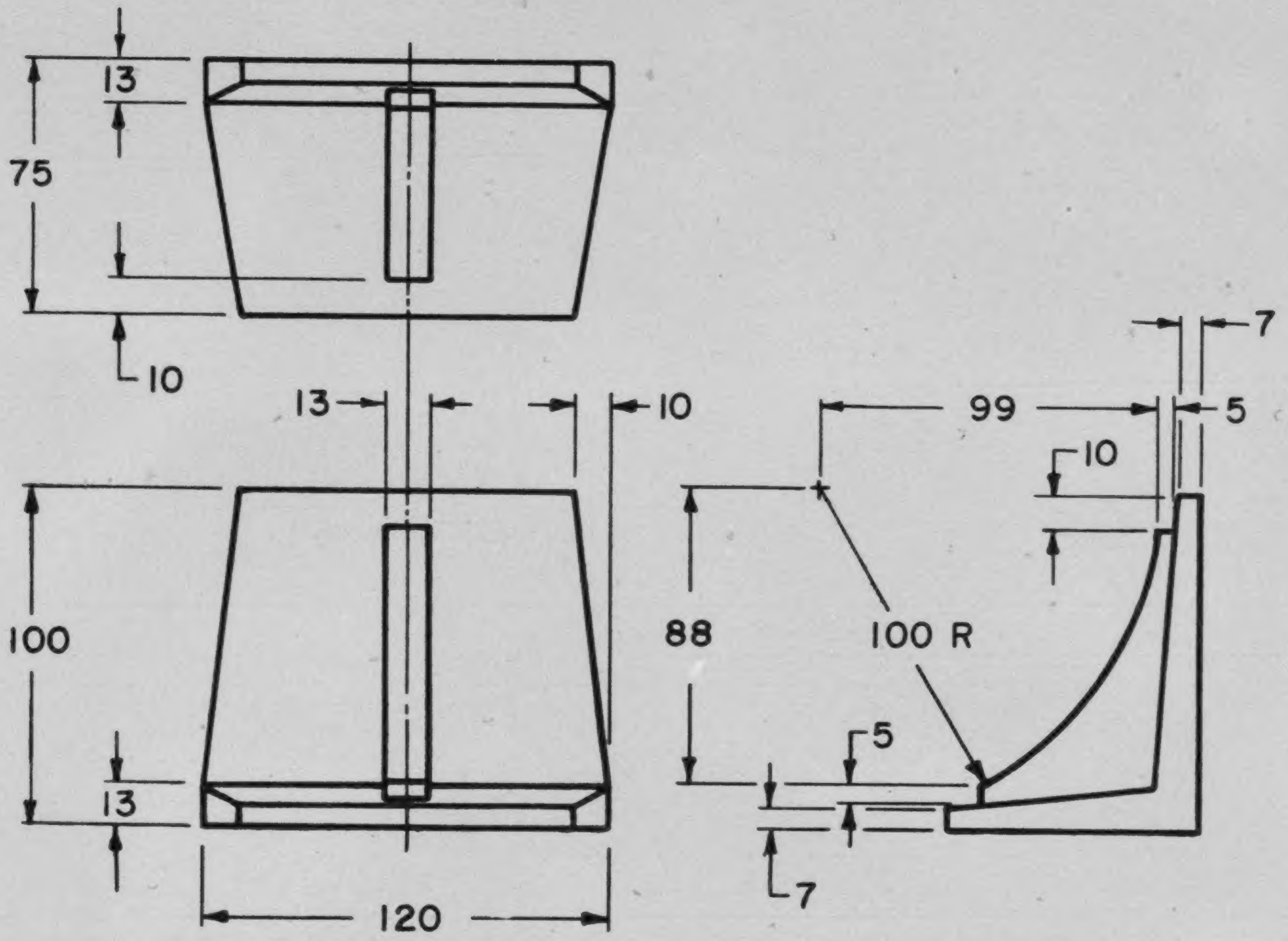
SCREW DRIVER

ALL DIMENSIONS IN mm

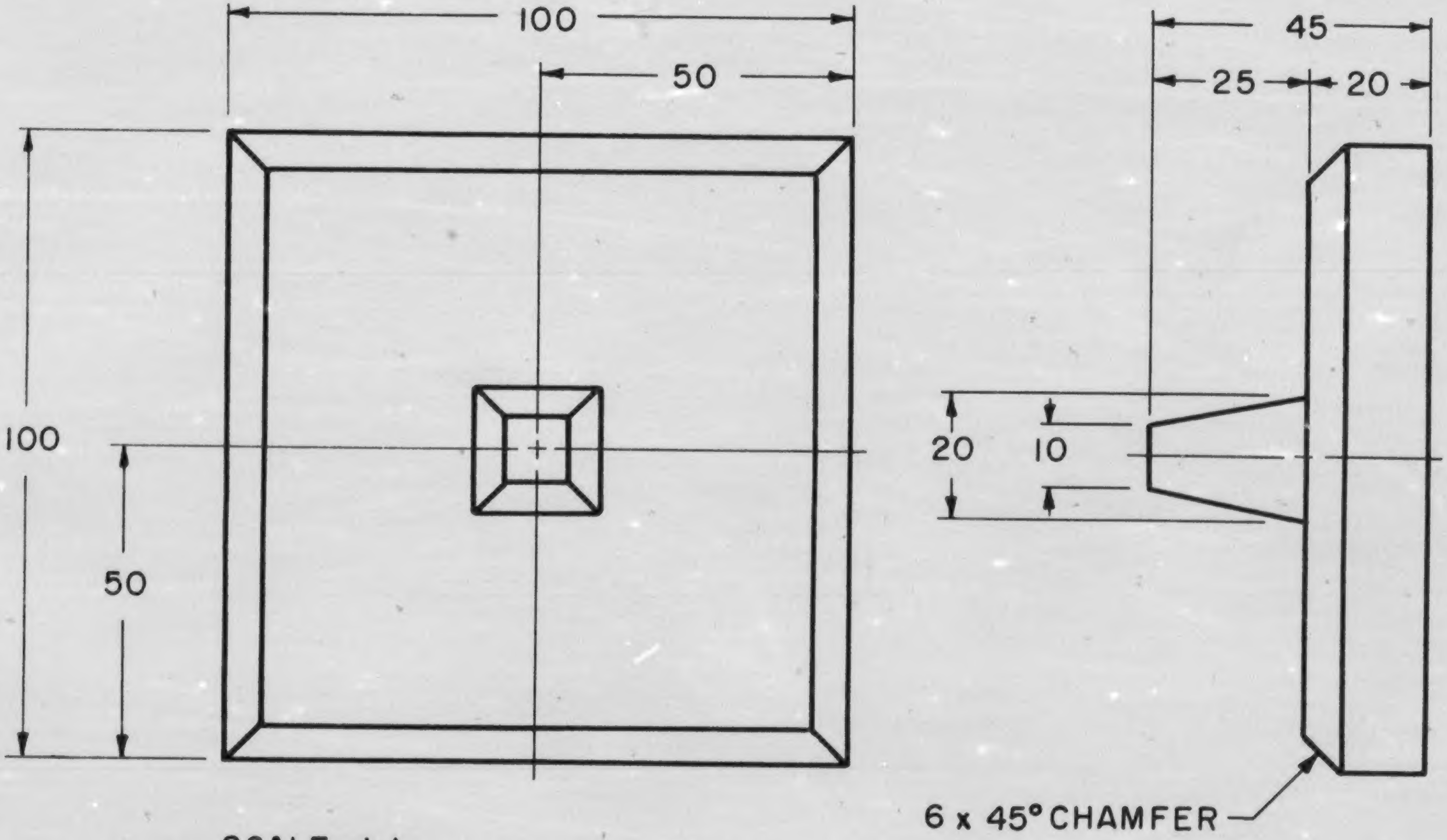

METRIC
9.5 DIA
1.5
17.5
77.5
16
14.5
12.5
11.5
11
11.5
5
20.5
25.5
19
2 BENDING POSTS REQ'D.
9.5 DIA +0.00
-0.25
19
9.5
47.5
45° CHAMFER - 1 WIDE


88.5 R
19 R
12.5
6.5
8
3
8 R
1.5 DIA
2.5 DRILL
5 SQUARE
4 R
SECTION
A-A
108
12.5
1.5
11
75
1.5
A
88.5 R
16
3
1.5 DIA
11 R
88.5 R
51
A
17.5
9.5
16 REAM
2 HOLES
47.5
22
38

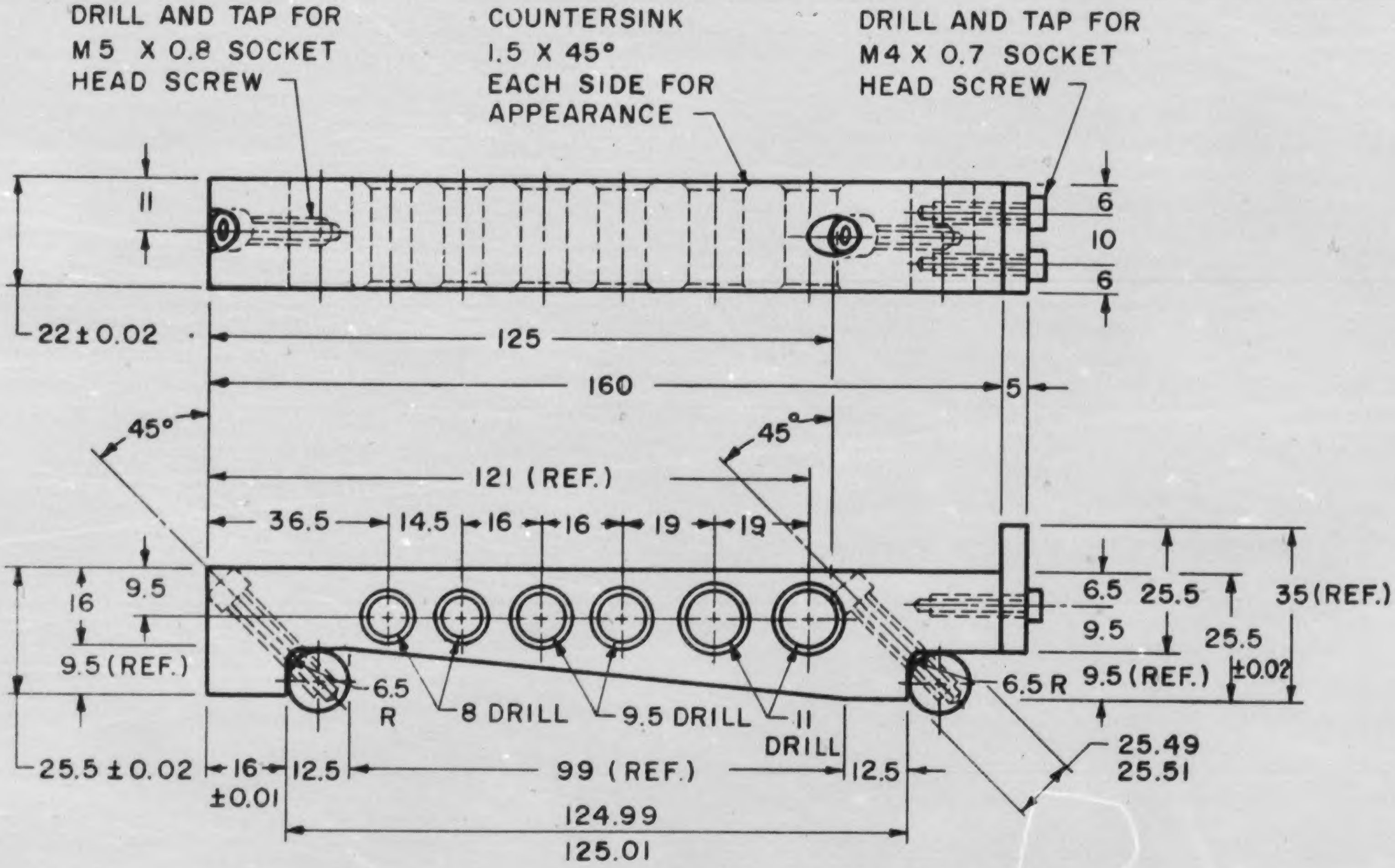
ALL DIMENSIONS IN mm


13
75
10
13
10
100
13
120
7
99
5
10
88
100 R
5
7

SCALE 1:2
ALL DIMENSIONS IN mm


100
50
100
50
45
25
20
20
10
6 x 45° CHAMFER

SCALE 1:1
ALL DIMENSIONS IN mm


DRILL AND TAP FOR M5 X 0.8 SOCKET HEAD SCREW
COUNTERSINK 1.5 X 45° EACH SIDE FOR APPEARANCE
DRILL AND TAP FOR M4 X 0.7 SOCKET HEAD SCREW
11
22 ± 0.02
125
160
5
6
10
6
45°
45°
121 (REF.)
36.5
14.5
16
16
19
19
9.5
16
9.5 (REF.)
6.5 R
8 DRILL
9.5 DRILL
11 DRILL
6.5 R
6.5
9.5
25.5
25.5 ±0.02
35 (REF.)
9.5 (REF.)
25.49
25.51
25.5 ± 0.02
16 ±0.01
12.5
99 (REF.)
12.5
124.99
125.01

GRIND ALL OVER SCALE 1:1 ALL DIMENSIONS IN mm

TEST--TECHNICAL

1. The SI unit of force is (one right):
   A. newton
   B. pascal
   C. joule
   D. hertz
2. A mass of one kilogram would have a force of gravity at sea level of:
   A. 98 N
   B. 9.8 N
   C. 1.6 N
   D. 99.8 N
3. The force of gravity at Tranquility Base (on the Moon) on a mass of one kilogram would be:
   A. 9.8 N
   B. 1.6 N
   C. 3.2 N
   D. 8.1 N
4. The SI unit of pressure is:
   A. newton
   B. pascal
   C. joule
   D. coulomb
5. One psi is equal to approximately:
   A. 7 kPa
   B. 9 kPa
   C. 15 kPa
   D. 25 kPa
6. The threads on a standard metric micrometer have a pitch of:
   A. 1 mm
   B. 0.5 mm
   C. 2 mm
   D. 0.2 mm
7. A millimetre dimension of 0.01 mm is equal to approximately:
   A. 0.004 inches
   B. 0.0004 inches
   C. 0.04 inches
   D. 0.4 inches
8. A tolerance of ten thousandths in the customary system would be equivalent to approximately:
   A. 0.025 mm
   B. 0.25 mm
   C. 2.5 mm
   D. 0.0025 mm

9. The abbreviation for the International System of Units adapted in 1960 is:
   A. SI
   B. S.I.
   C. ISO
   D. MKS

10. The symbol for the International Organization for Standardization is:
   A. ISO
   B. SI
   C. ISI
   D. ISB

11. The SI unit of energy is:
   A. hertz
   B. joule
   C. pascal
   D. coulomb

12. The SI unit of power is:
   A. joule
   B. watt
   C. horsepower
   D. BTU

13. The SI unit of speed or velocity is:
   A. kilometre per hour
   B. metre per second
   C. kilometre per second
   D. metre per minute

14. A large Calorie is equal to approximately:
   A. 8 kJ
   B. 4.2 kJ
   C. 10 kJ
   D. 12 kJ

15. The SI unit of density is:
   A. grams per cubic metre
   B. kilograms per cubic metre
   C. kilograms per cubic decimetre
   D. grams per cubic decimetre

EVALUATION

The two basic methods of evaluating students' ability to use the metric system and to convert from customary to metrics and vice-versa is by a written test and practical applications. The sample technical test above can be used. There are several methods of evaluating a student's ability to use metrics in machine shop, applied drafting and print reading. One technique is to require that students convert drawings into metric. A second method is to use print reading exercises in which various types of drawings are involved including dual dimensioning, all metric and metric with the customary readout chart. A third technique is to evaluate a student's ability to work from a metric print and to produce a part to metric measurements within the specified limits and tolerances.

TOOLS AND EQUIPMENT

To produce parts to metric measurement, it is necessary to have tools and machines with metric capabilities. A list of measuring tools and their sources follow. In addition, it is necessary to convert existing machine tools to metric capabilities.

For lathes and grinders, the best way to convert is to add a dual reading dial to the various feed components. In addition, one lathe should be converted for cutting all metric threads by using a conversion gear kit. Whenever a new lathe or grinder is purchased, either a machine with dual capabilities or an all metric machine should be considered.

There are several ways to convert a milling machine. The simplest is to add dual reading dials. The more complex method is to remove the lead screw and nuts, replace the lead screw and nuts and add an all metric dial. The most practical method of converting milling machines is to add a digital readout unit that will read both in inches and millimetres.

METRIC TOOL LIST FOR MACHINE SHOP

Dial Indicator	10 mm
Drill Index	1 mm to 5.9 mm
Drill Index	6 mm to 12 mm
Inside Micrometer	5 mm to 25 mm
Direct Reading Digit Micrometer	0-25 mm
Anglometric Micrometer	0-25 mm
Anglometric Micrometer	50 mm to 75 mm
Gage Blocks - 37 pieces	Metric
Screw Pitch Gage	0.25 mm to 6 mm
Stainless Steel Comparison Rules	150 mm/6 inch
Stainless Steel Rules	300 mm/12 inch
Sine Bar	
Vernier Caliper	150 mm

40-piece Tap and Die Set	Metric and Metric Fine Taps and Dies
Assorted Bolts, Nuts, Screws	all sizes
Pull Tape Measure	Dual-reading, 2 m

Metric Tool Suppliers

A. O. K. Tool Corporation
82-21 Sutter Avenue
Ozone Park, New York 11417

Brown & Sharpe Manufacturing Company
Industrial Products Division
Precision Park
North Kingstown, Rhode Island 02852

Mitutoyo Manufacturing Company, Ltd.
11 East 26th Street
New York, New York 10010

Regal Beloit Tool Corporation
P. O. Box 128
South Beloit, Illinois 60085

Roe & Sons, Inc.
Patchogue, New York 11772

Stanley Tools
New Britain, Connecticut 06050

The L. S. Starrett Company
Athol, Massachusetts 01331

Zelenda Machine Tool Corporation
Metric Division
66-02 Austin Street
Forest Hills, New York 11374

Section 3

METRICS FOR BILINGUAL EDUCATION

One of the major concerns in vocational education is to provide adequate instruction for the person who is bilingual. A bilingual person is one who has the ability to communicate and understand in two languages; it is the ability to function in each language independently of the other. A large segment of the school population in the United States uses Spanish as either their first or second language. Therefore, it is very important to provide metric conversion materials in Spanish.

As part of the original project entitled, Metrication of Technical Career Education, six kits of instructional material were developed in the areas of GOING METRIC FOR CAREER TEACHERS, GOING METRIC FOR STUDENTS, GOING METRIC IN DRAFTING, GOING METRIC IN MACHINE SHOP, GOING METRIC IN GRAPHIC ARTS, and GOING METRIC IN WOODWORKING AND BUILDING CONSTRUCTION. It was decided that the first of these packets, namely GOING METRIC FOR CAREER TEACHERS, would be most adaptable and most useful in Spanish instruction.

In addition, it was decided to revise the packet of material entitled GOING METRIC FOR STUDENTS into a more practical, forty-nine page bulletin entitled THE METRIC SYSTEM FOR EVERYDAY USE. As part of this phase of the project, it was also decided to produce a Spanish version of the National Bureau of Standards Special Publication 304A entitled THE MODERNIZED METRIC SYSTEM.

Before the Spanish editions of these materials were produced, they were first prepared in English to make certain that all information was accurate. These were checked by Mr. Lou Sokol, President of the U.S. Metric Association, and Mr. Lou Barbrow of the Metric Information Office, National Bureau of Standards.

As a first step in preparing the Spanish editions, it was decided to hire Spanish-speaking people who were involved in the area of vocational and technical education to do the actual translation. A major problem became evident when visiting with the head of the

Spanish Division of the language department at Western Michigan University. While Spanish is a widely-spoken language throughout the United States, it is not a single or consistent language. There are three major adaptations of pure Spanish; namely the Cuban Spanish spoken by the population primarily located in the Miami area, Puerto Rican Spanish spoken by the population primarily located in New York and around other major cities in the United States, and the native-born Spanish spoken primarily by people of the Southwest. Because of these variations in spelling and pronunciation, it was decided to translate the materials to as pure a Spanish form as possible. To do this, the services of three individuals were utilized.

1. Mr. S. C. Dillon, whose primary, secondary and college work was done in Lima, Peru, and who is currently Area Manager for Latin America of Clark International Marketing Group. Since Clark Equipment is one of the forerunners of metric conversion, particularly in the area of off-the-road vehicle manufacturing, we felt that this individual would be appropriate to do part of the translation.
2. To reinforce this work, Ines Good, who is a native of Bogota, Colombia, and who received all of her language at the elementary, secondary and university in that country, also did translation work. At the time Ms. Good was a graduate assistant at Western Michigan University and her brother was enrolled in engineering at the University. Both of these individuals provided a proper background for translation into Spanish.
3. To recheck the preliminary form, the services of Mr. Herbert Jones, Chairman of the Spanish Division of the Modern and Classical Language Department at Western Michigan University were utilized.

The first set of Spanish materials entitled GOING METRIC FOR CAREER TEACHERS was completed in June of 1975. Figure 3-1. At that time an attempt was made to make the material available to CEDar labs and centers throughout the United States that had an interest in bilingual education. The list of participating institutions was obtained from the National Institute of Education and a letter, as shown in Figure 3-2, was sent to each institution offering these materials providing they would be evaluated. In addition, the materials were made available to the American Institute for Research at Palo Alto, California, and to other interested groups as shown in Figure 3-3. In each case the individuals were asked to fill out an evaluation form, or indicate their comments by letter. These comments appear as Figure 3-4.

On May 1, 1975, a meeting was held with Mrs. Maria Guadalupe Tousek to discuss the use of these Spanish materials in bilingual programs. It was agreed that she would use these materials in courses of Spanish-speaking students in technical and vocational education. The material was to be evaluated and returned to the Center.

An article appeared in the February 1976 issue of THE SCIENCE TEACHER (Figure 3-5) as well as the AIR METRIGRAM indicating that the material GOING METRIC FOR CAREER TEACHERS, Spanish edition, was available. As a result, several other individuals and groups requested copies of these materials.

Because of the difficulty in obtaining proper translation and also because of production problems, the four-color chart entitled THE MODERNIZED METRIC SYSTEM was not available until late March. This chart appears as Figure 3-6.

The forty-nine page bulletin entitled THE METRIC SYSTEM FOR EVERYDAY USE, Spanish edition, was completed about the middle of April, 1976. Figure 3-7. Both of these publications are being mailed to a select group of individuals who have expressed an interest in bilingual material.

Figure 3-1

Note to User:

The enclosed Spanish version of the material entitled, GOING METRIC FOR CAREER TEACHERS, was originally developed in English as part of a larger project by the Center for Metric Education. In making this translation into Spanish the Center used the services of native Spanish-speaking individuals from two South American countries as well as an expert from the Spanish Department at Western Michigan University. Each had a slightly different translation, and therefore, it was necessary to make some compromises.

This experience made it apparent to us that there was no possible way of producing material in Spanish so that it would completely satisfy every different geographic part of the United States where Spanish is spoken and used.

This instructional material has been prepared in as pure a Spanish form as is possible. Teachers who plan to use this material in different regions of the country will have to make the necessary adaptions to meet the needs of their particular students.

Sincerely,

John L. Feirer

John L. Feirer
Director
Center for Metric Education

jr

CONVIRTIENDOSE A LO METRICO PARA MAESTROS PROFESIONALES

NOTAS Y COMENTARIOS

1. ISLAS EN UN MUNDO METRICO. Los Estados Unidos es la última gran nación industrial en adoptar el sistema métrico, "convertirse a lo métrico."
2. COSAS QUE MEDIMOS. Cada día billones de medidas son tomadas en la industria, el comercio y por el consumidor.
3. SISTEMAS DE MEDIDAS. Los tres sistemas de medidas son:
    1. El usual, comunmente llamado Inglés en los Estados Unidos e Imperial en el Reino Unido, Canadá y Australia.
    2. El sistema métrico antiguo el cual incluye el CGS-centímetro, gramo y segundo; y el MKS-metro, kilogramo y segundo. Las unidades métricas de la variedad del metro, gramo, litro, y centígrado tienen solamente 175 años pero se usan mucho. Desafortunadamente muchas son ahora inexactas e imperfectas.
    3. SI-métrico, el sistema internacional de unidades de medida llamado "SI" por su nombre básico--Système International d'Unités--es una versión modernizada del sistema métrico que fué establecida en 1960.
4. TRES TIPOS PRINCIPALES DE SISTEMAS DE MEDIDA.
5. SISTEMA INTERNACIONAL DE UNIDADES. Hay siete unidades básicas y dos unidades suplementarias, más una gran cantidad de unidades derivadas.
6. DISPOSICION DE SIMBOLOS DEL SISTEMA INTERNACIONAL DE UNIDADES. Observe que todos los símbolos son letras minúsculas a excepción de aquellas a las cuales se les dio el nombre de

científicos importantes tal como el kelvin, por Lord Kelvin, un científico Británico.

7. PREFIJOS, EXPONENTES, Y SIMBOLOS. Todas las unidades básicas tienen los mismos prefijos, exponentes y símbolos. Las tres más usadas son la unidad básica, mil veces la unidad básica, y la milésima parte de la unidad básica. Por ejemplo, para la longitud se usarían el metro, el kilómetro y el milímetro.

8. LA FAMILIA DEL SI METRICO. (primera hoja) Aquí usted puede ver cinco de los hermanos--el metro, el kilogramo, el kelvin, el segundo y el ampério. Debido a que el kelvin se usa solamente en trabajo científico, el grado Celcio se usa en las actividades diarias. El litro se llama primo porque es una unidad derivada.

9. LA FAMILIA DEL SI METRICO. (segunda hoja) Dos más de la familia SI han sido usadas por muchos años también en el sistema usual incluyendo la candela y la molécula. Algunas de las otras unidades derivadas incluyen el newton, el vatio, el julio y el pascal.

10. ESTA ES LA MANERA COMO SE DESARROLLO EL SISTEMA USUAL (INGLES). Observe que el sistema usual se basó en el cuerpo humano, mientras que el sistema métrico se basó originalmente en la distancia delpolo norte al ecuador.

11. EL HOMBRE COMO VARILLA DE MEDIDA. Todas las unidades originales del sistema usual están relacionadas con el cuerpo humano directa o indirectamente.

12. CONOZCA AL HERMANO METRO. No hay comentario.

13. YO SOY EL HERMANO METRO. Observe que el metro es un poco más largo que la yarda.

14. AQUI VEMOS COMO LA MEDIDA METRICA SE COMPARA CON EL PIE. La pulgada es exactamente igual a 25.4 milímetros. Cuatro pulgadas serían 101.6 milímetros o aproximadamente 102.

15. AHORA DETENGASE Y PIENSE. Observe como el sistema métrico es muy similar a nuestro sistema monetario. Ambos son sistemas decimales y tienen nombres similares. Las tres medidas más usadas para pequeñas distancias son el metro, el centímetro y el milímetro. Estos son muy fáciles de recordar en relación con el dolar, 100 centavos y mil milésimas de dolar, respectivamente.

16. LA DIVISION MAS PEQUEÑA EN MI ES UN MILIMETRO. Observe como un milímetro es casi la mitad del camino entre 1/16 y 1/32. Los estudiantes deben formarse una idea del tamaño real de un milímetro.

17. AHORA TOMEMOS UNA PELOTA. Se puede estudiar su tamaño métrico y se les puede preguntar a los estudiantes el equivalente del tamaño en pulgadas.

18. Y EXAMINEMOS SUS MONEDAS. El grosor de una moneda de diez centavos es una buena referencia para estimar un milímetro (1 mm) y una moneda de cinco centavos para estimar dos milímetros (2 mm).

19. UN KILOMETRO. Verbalmente haga notar que el acento va sobre la segunda sílaba: ki-ló-me-tro. El kilómetro es casi 5/8 de milla.

20. TODOS LOS DEPORTES INTERNACIONALES SE MIDEN CON EL SISTEMA DEL SI METRICO. Cualquier estudiante que haya mirado las transmiciones televisadas de las Olimpiadas habrá escuchando que todas las medidas se transmiten en términos del sistema métrico.

21. UN VASO CON AGUA. Para comenzar a pensar métricamente, es buena idea capacitarse en estimar tamaños. ¿Cuál es el tamaño de un vaso con agua? ¿Qué altura tiene?

22. UNA CAJA DE FOSFOROS. No hay comentario.

23. JUGADORES DE BASKETBOL. ¿Sería un buen centro un jugador de básketbol de dos metros de altura?

24. CONOZCA AL HERMANO KILOGRAMO. No hay comentario.

25. YO SOY EL HERMANO KILOGRAMO. No hay comentario.

26. KILOGRAMO. Un kilogramo de mantequilla sería un poco más de dos libras. El uso del término "kilo" es incorrecto.

27. UN KILOGRAMO (kg) ES IGUAL A 1000 GRAMOS (g). No hay comentario.

28. UNA MONEDA DE CINCO, PESA ALREDEDOR DE CINCO GRAMOS. ¿Recuerda el estudiante el grosor de una moneda de cinco centavos?

29. PARA PESOS MUY PEQUEÑOS. No hay comentario.

30. PARA PESOS MAS GRANDES SE USA LA TONELADA METRICA. Una tonelada métrica se llama "tonne" en el SI-métrico.

31. MUCHOS COMESTIBLES Y PRODUCTOS CASEROS ESTAN MARCADOS CON EL PESO USUAL (INGLES) Y EL PESO METRICO. ¿Son 14 onzas exactamente 397 gramos?

32. CONOZCA AL PRIMO HERMANO LITRO. No hay comentario.

33. LECHE. El litro tiene casi 6 por ciento más que el cuarto.

34. EN EL SISTEMA METRICO HAY UNA RELACION DEFINIDA ENTRE LAS UNIDADES. Es importante señalarle a los estudiantes cuánto valor tiene el aprender un nuevo sistema de medidas. Haga notar que en el sistema usual no hay relación entre capacidad, masa, peso, y longitud.

35. TRES MEDIDAS PARA RECORDAR. No hay comentario.

36. CONOZCA AL HERMANO CELCIO--LA UNIDAD DE TEMPERATURA. No hay comentario.

37. LA TEMPERATURA DEL HERMANO CELCIO. Observe que el término *centígrado* no se usa más aunque comunmente se encuentra en libros de química y física. ¿Cuál sería la temperatura, en grados Celsios, de un buen día para esquiar en la nieve?

38. 25 GRADOS FAHRENHEIT Y 25 GRADOS CELCIOS. Observe que uno es una escena de invierno y el otro una escena de verano.

39. TEMPERATURA. No hay comentario.

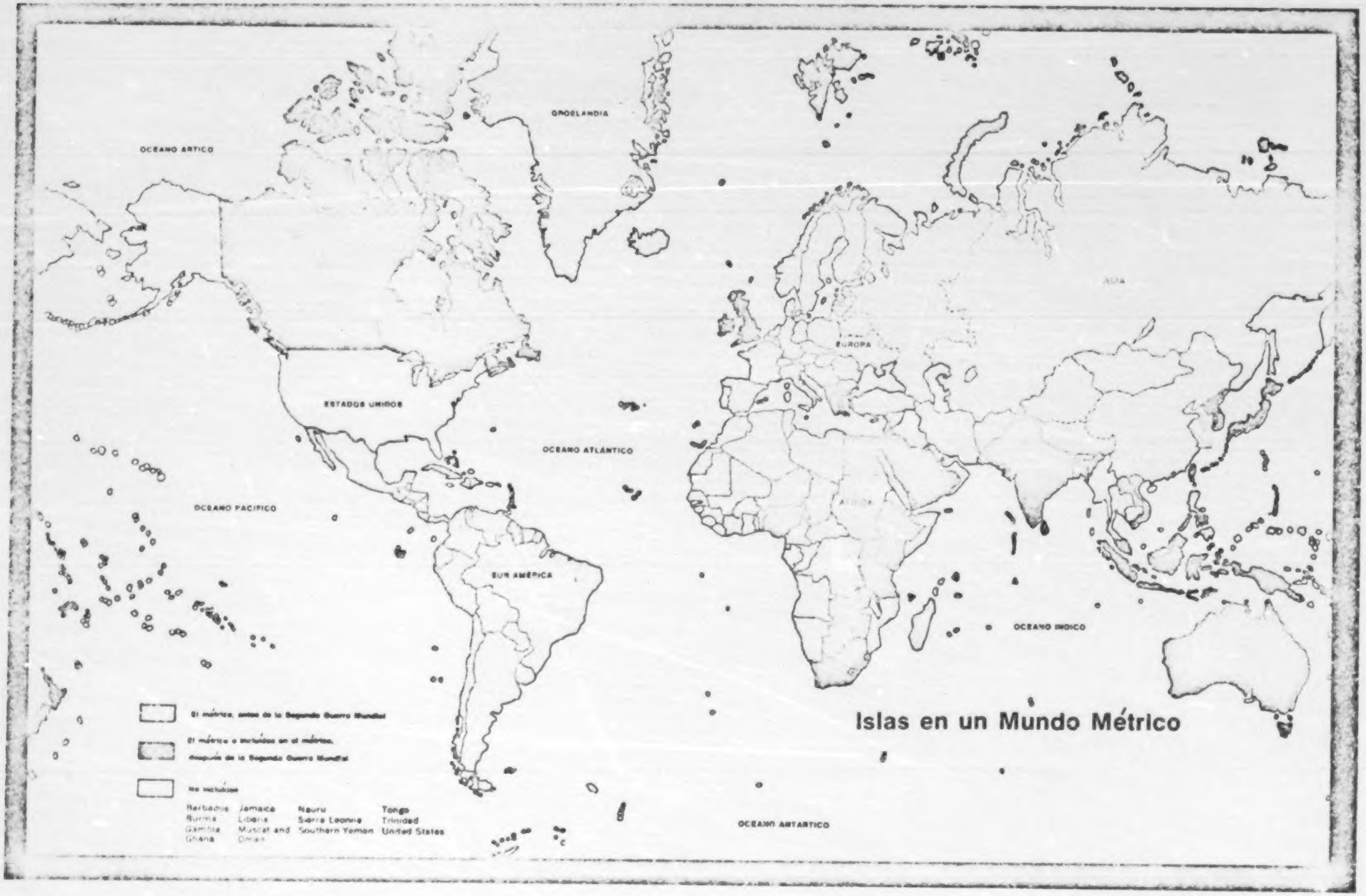
40. EL HERMANO SEGUNDO. No hay comentario.

41. EL HERMANO AMPERIO. No hay comentario.

42. LA HERMANA CANDELA. No hay comentario.

43. LA HERMANA MOLECULA. No hay comentario.

44. ECUACION METRICA SIMPLIFICADA--ECUACION USUAL DE ESTADOS UNIDOS. Observe lo fácil, que es cambiar en el sistema métrico, de las unidades más grandes a las más pequeñas o vice-versa, en contraste con el sistema usual.


OCEANO ARTICO
GROELANDIA
ASIA
EUROPA
ESTADOS UNIDOS
OCEANO ATLANTICO
OCEANO PACIFICO
AFRICA
SUR AMERICA
OCEANO INDICO
Islas en un Mundo Métrico
OCEANO ANTARTICO
El métrico, antes de la Segunda Guerra Mundial
El métrico o incluídos en el métrico, después de la Segunda Guerra Mundial
No incluídos
Barbados
Burma
Gambia
Ghana
Jamaica
Liberia
Muscat and Oman
Nauru
Sierra Leone
Southern Yemen
Tonga
Trinidad
United States

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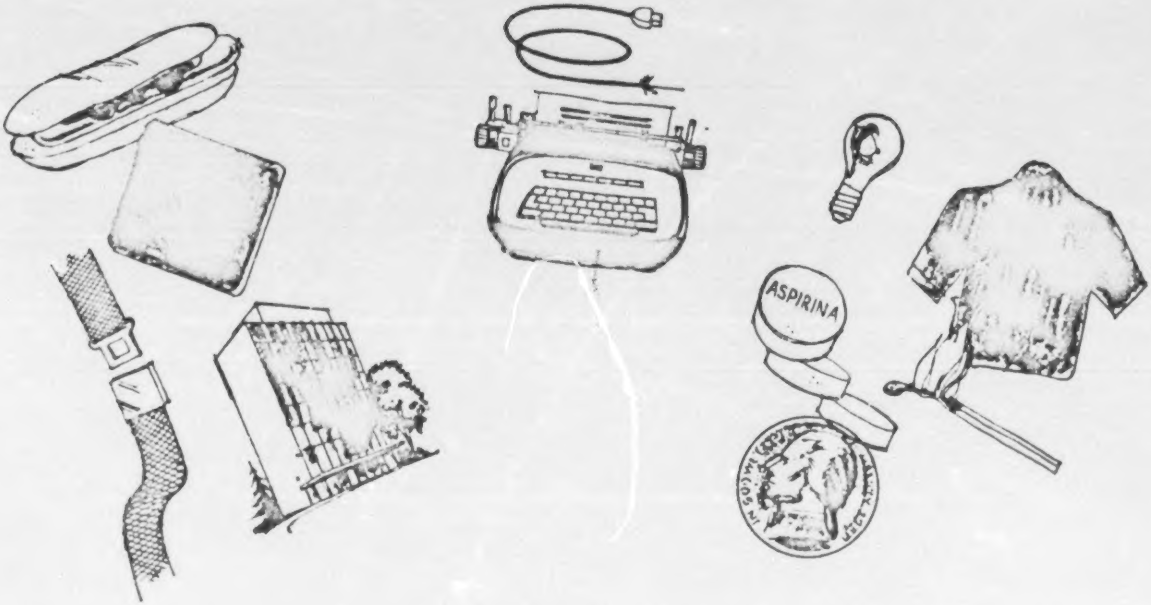
COSAS QUE MEDIMOS



USOE SPONS
GRAN

Clases de Sistemas de Medidas

1. El Usual
2. El Métrico
3. El SI Métrico

Los Tres Tipos Principales de Sistemas de Medidas

I. El Sistema Usual: Este es el sistema de medida que más se usa en los Estados Unidos. Este sistema incluye unidades que se usan comunmente, tales como: la pulgada, el pie, layarda, la milla, la pinta, el cuarto, el galón, la libra, el grado Fahrenheit, etc.

II. El Sistema Métrico: Este es un sistema de medida que usa el metro como unidad de longitud. Al principio, el metro se definió como una diez millonésima parte de la distancia del polo al ecuador. Sinembargo, con este sistema de medida se encontraron diferencias entre las naciones que lo usan. Así que el sistema métrico no fue un patrón confiable y en el frabajo científico no hubo cabida para malentendidos y errores.

III. El Sistema Internacional de Medidas (SI): Este es el sistema métrico que ha sido mejorado e igualado por una Conferencia General de Pesos y Medidas. Este sistema métrico patrón se fundamentó en siete unidades básicas que incluyen el metro, el kilogramo, el segundo, el amperio, la candela, el kelvin, y la molécula.

SISTEMA INTERNACIONAL DE UNIDADES (SI)

Las Siete Unidades Básicas

1. El Metro: Unidad de longitud
2. El Kilogramo: Unidad de masa
3. El Segundo: Unidad de tiempo
4. El Amperio: Unidad de corriente eléctrica
5. El Kelvin: Unidad de temperatura
6. La Candela: Unidad de intensidad luminosa
7. La Molécula (el mol): Unidad de cantidad de substancia

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Símbolo

______________________________ m

______________________________ kg

______________________________ s

______________________________ A

______________________________ K

______________________________ cd

______________________________ mol

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PREFIJOS, EXPONENTES, y SIMBOLOS

Forma Decimal	Exponente o Poder	Prefijo	Pronunciación	Símbolo	Significado
1 000 000 000 000	= 10^{12}	tera	tĕr′ á	T	trillón
1 000 000 000	= 10^{9}	giga	ǰi′ gá	G	billón
1 000 000	= 10^{6}	mega	mĕg′ á	M	millón
1 000	**= 10^{3}**	**kilo**	**kĭl′ ō**	**k**	**mil**
100	= 10^{2}	hecto	hĕk′ tō	h	cien
10	= 10^{1}	deka	dĕk′ â	da	diez
1					**unidad básica**
0.1	= 10^{-1}	deci	dĕs′ ī	d	décima
0.01	= 10^{-2}	centi	sĕn′ tĭ	c	centésima
0.001	**= 10^{-3}**	**milli**	**mĭl ĭ**	**m**	**milésima**
0.000 001	= 10^{-6}	micro	mī′ krô	μ	millonésima
0.000 000 001	= 10^{-9}	nano	năn′ ô	n	billonésima
0.000 000 000 001	= 10^{-12}	pico	péc ô	p	trillonésima
0.000 000 000 000 001	= 10^{-15}	femto	fĕm′ tò	f	cuadrillonésima
0.000 000 000 000 000 001	= 10^{-18}	atto	ăt′ tô	a	quintrillonésima

▨ los más usados

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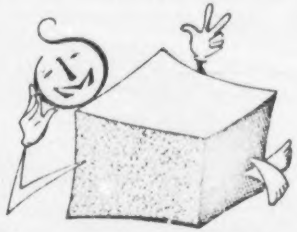
La Familia del SI METRICO

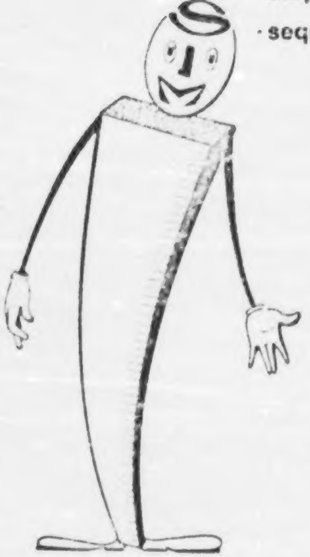
5 HERMANOS
- metro
- kilogramo
- kelvin(celsio)
- amperio
- segundo

2 HERMANAS
- candela
- molécula

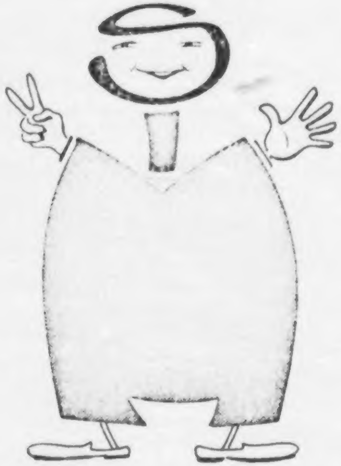
1 PRIMO
- litro



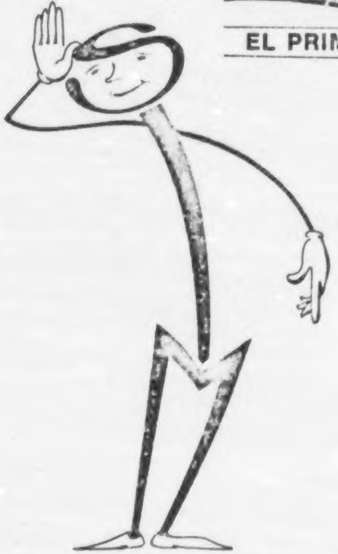
EL PRIMO HERMANO litro



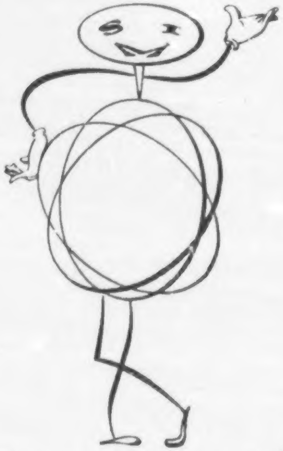
EL HERMANO **metro**
(longitud)



EL HERMANO **kilogramo**
(masa)



EL HERMANO **kelvin(celsio)**
(temperatura)



LA HERMANA **molécula**
(cantidad de
substancia)

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Más sobre la Familia del SI METRICO

EL HERMANO **amperio**
(corriente eléctrica)

EL HERMANO **segundo (el segundo)**
(tiempo)

LA HERMANA **candela**
(intesidad luminosa)

y otros primos segundos
tales como:

- newton
- julio
- vatio
- pascal

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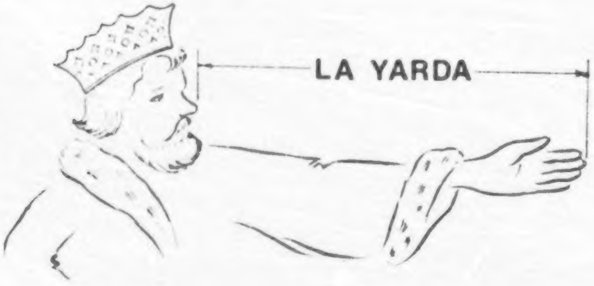
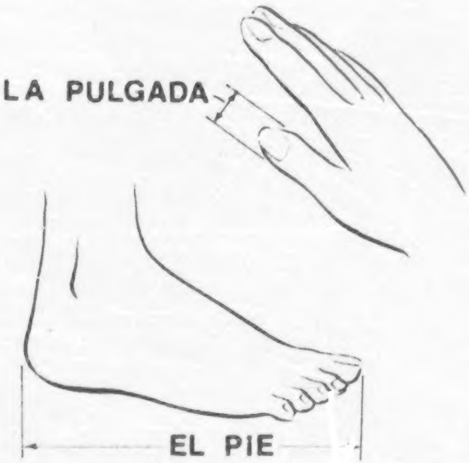
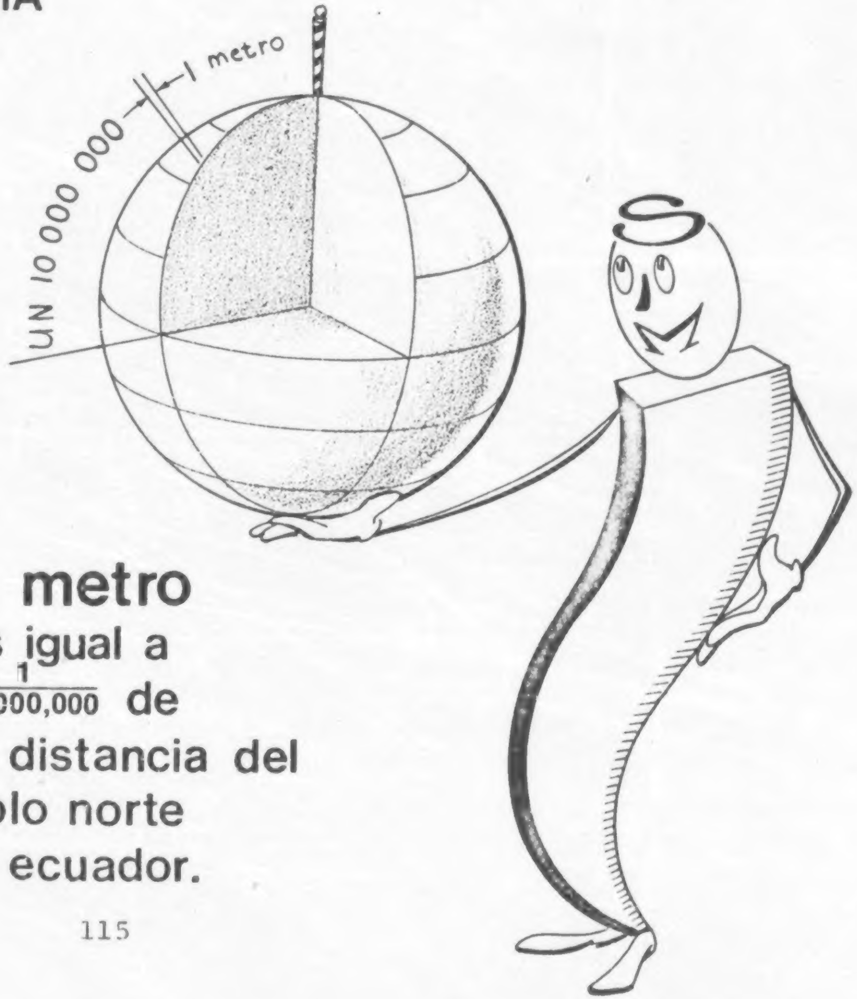
ESTA ES LA MANERA COMO SE DESARROLLO EL SISTEMA USUAL (INGLES).




LA PULGADA
EL PIE


1 metro
UN 10 000 000

El metro es igual a $\frac{1}{10,000,000}$ de la distancia del polo norte al ecuador.

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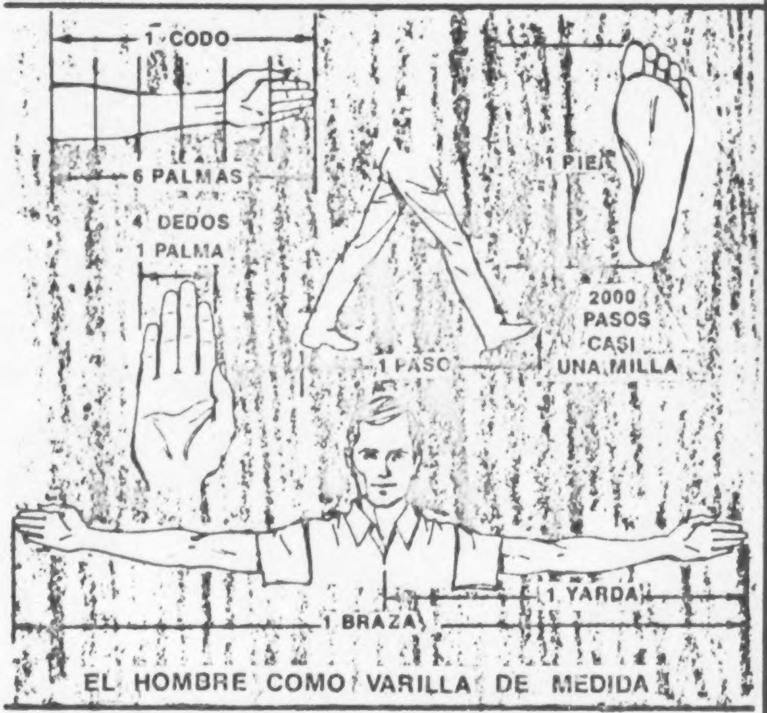

1 CODO
6 PALMAS
4 DEDOS
1 PALMA
1 PIE
2000 PASOS CASI UNA MILLA
1 PASO
1 YARDA
1 BRAZA

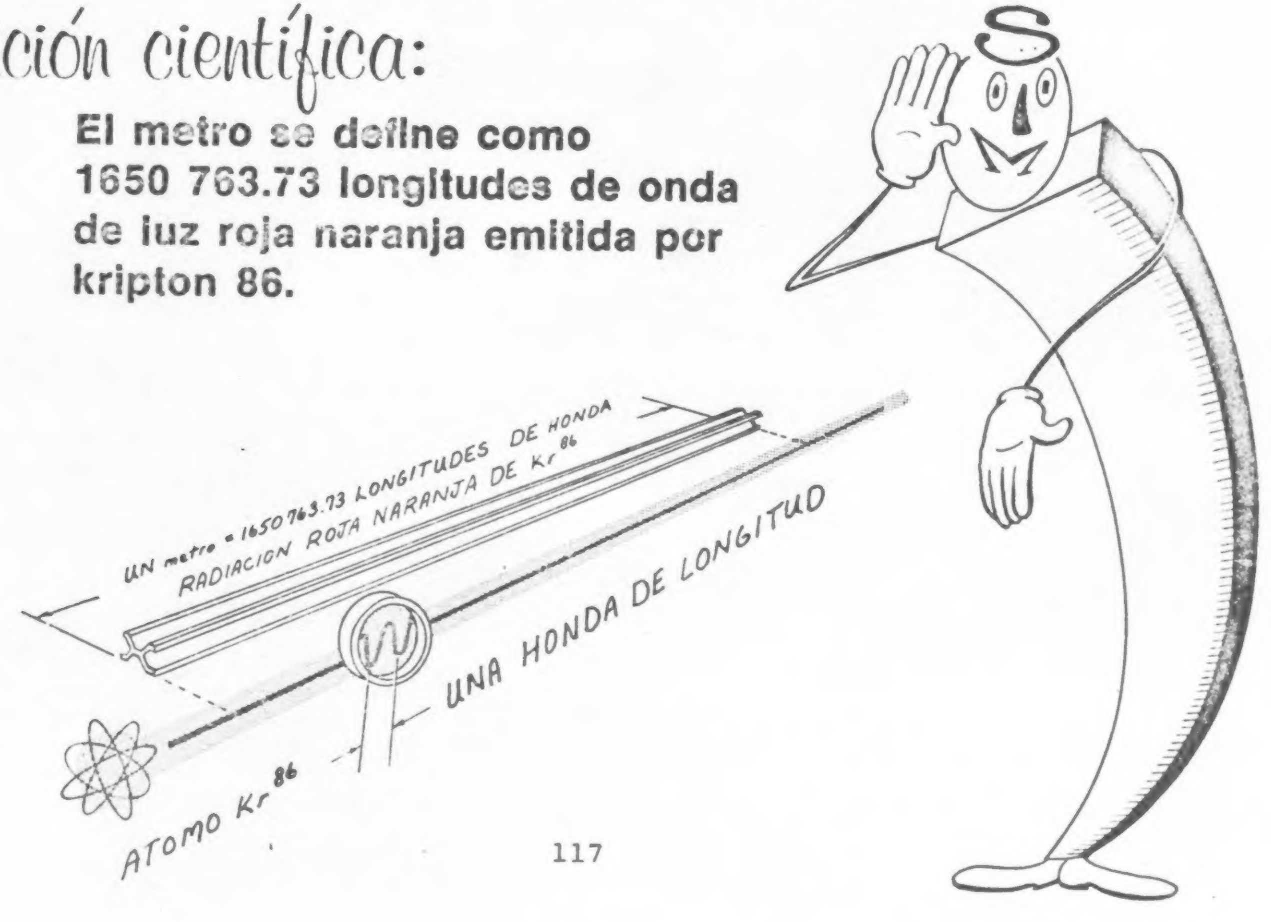
EL HOMBRE COMO VARILLA DE MEDIDA

Conozca AL HERMANO metro

la unidad básica de LONGITUD

definición científica:

El metro se define como 1650 763.73 longitudes de onda de luz roja naranja emitida por kripton 86.


UN metro = 1650 763.73 LONGITUDES DE HONDA
RADIACION ROJA NARANJA DE Kr 86
UNA HONDA DE LONGITUD
ATOMO Kr 86

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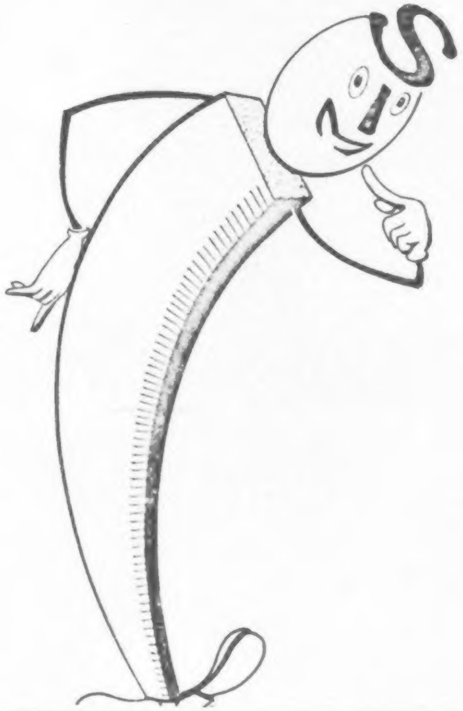
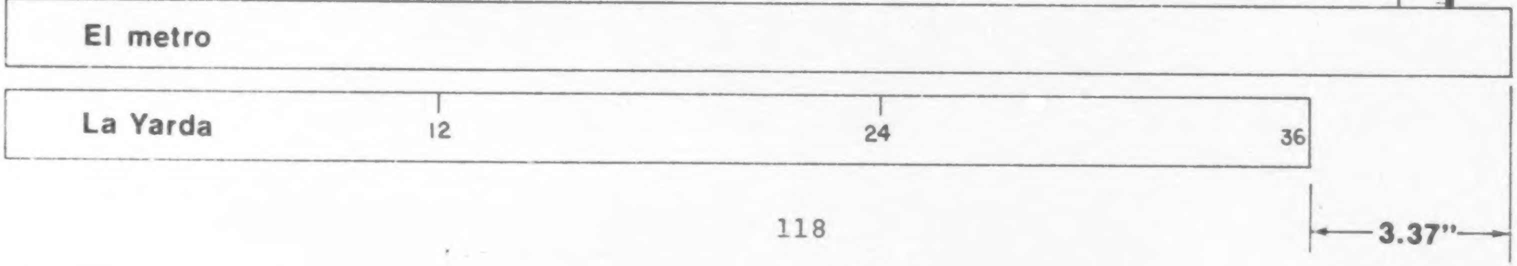


Yo soy el hermano **metro**
un miembro básico de la
familia del SI METRICO

tengo un poco más de
3 pulgadas de largo que
mi amiga la yarda.



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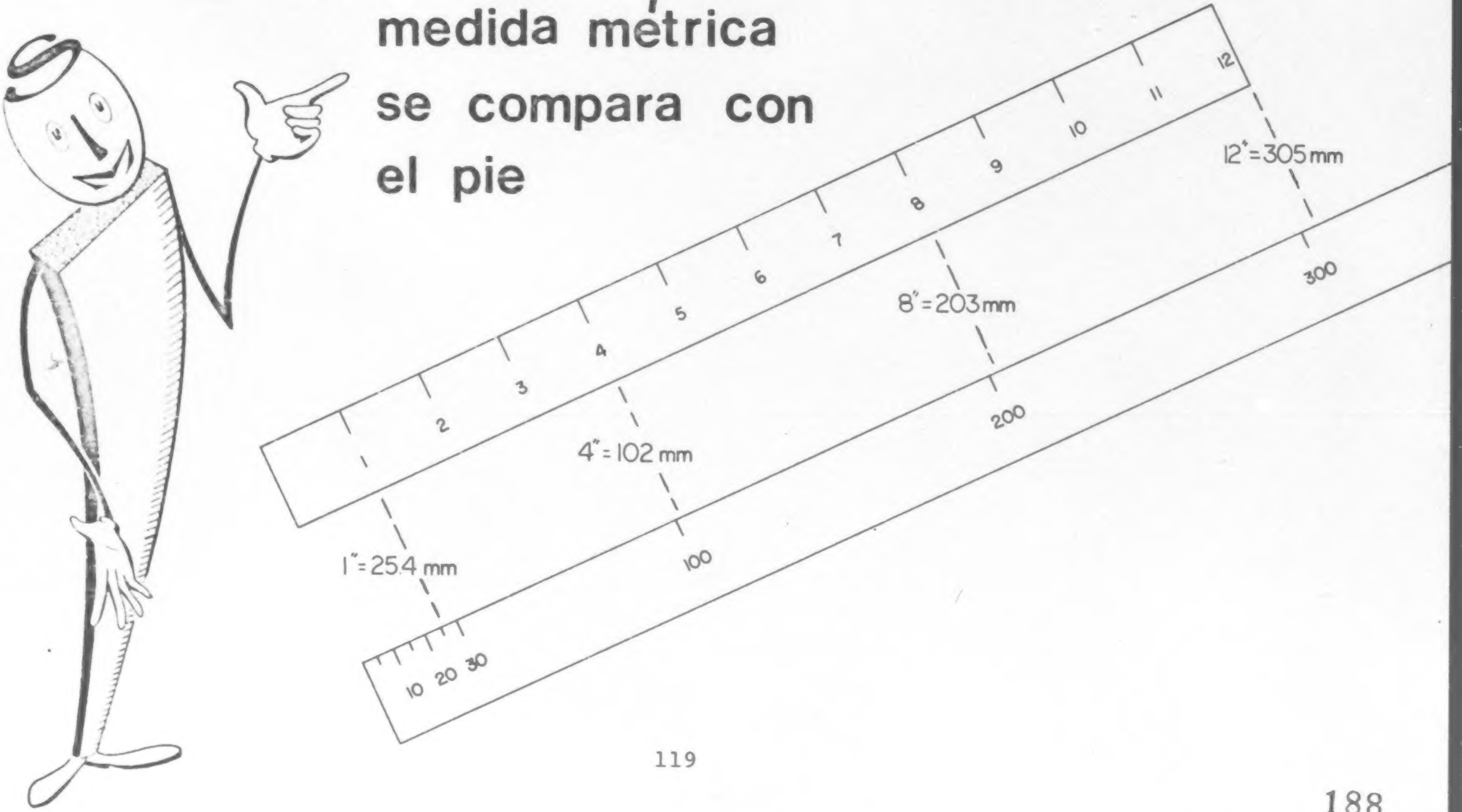
Aquí vemos como la medida métrica se compara con el pie


1
2
3
4
5
6
7
8
9
10
11
12
12" = 305 mm
8" = 203 mm
4" = 102 mm
1" = 25.4 mm
10
20
30
100
200
300

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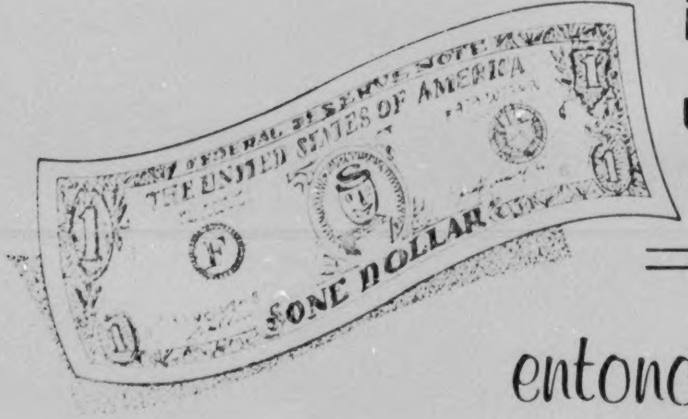
Ahora deténgase y piense

Si un dolar igualara a un metro –



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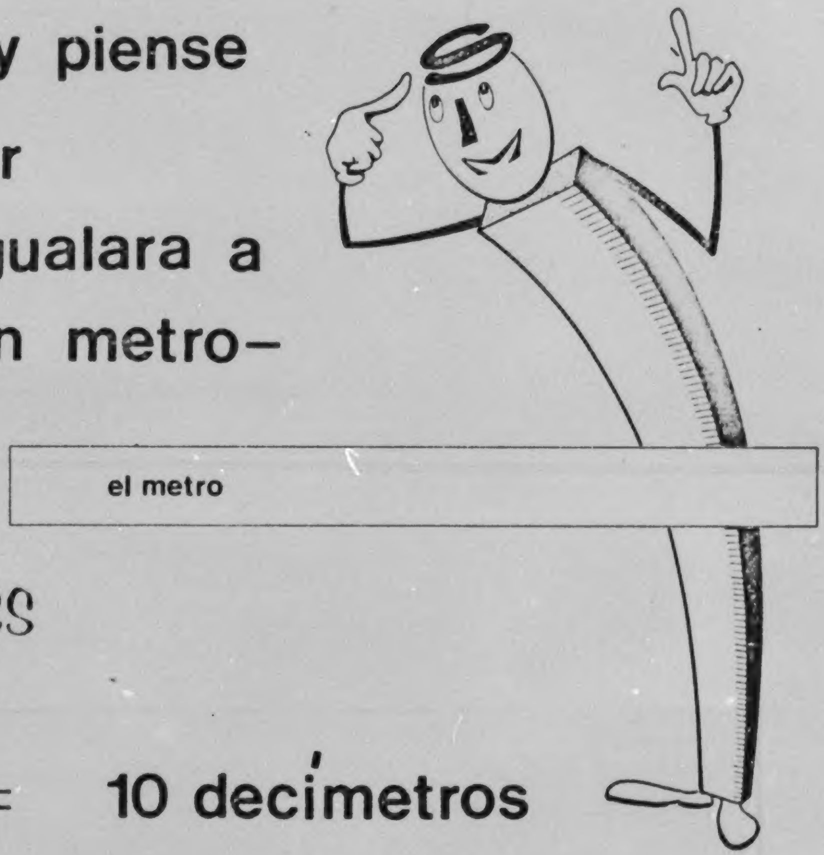
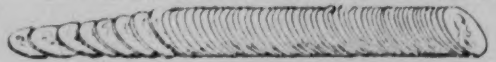


entonces

10 monedas de diez = 10 decímetros



100 centavos = 100 centímetros

1000 milésimos = 1000 milímetros

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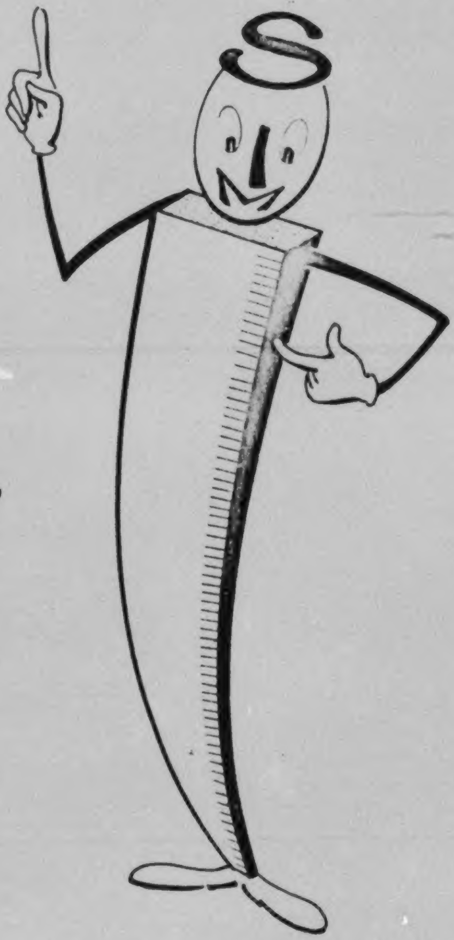
La división más pequeña en mí es un milímetro



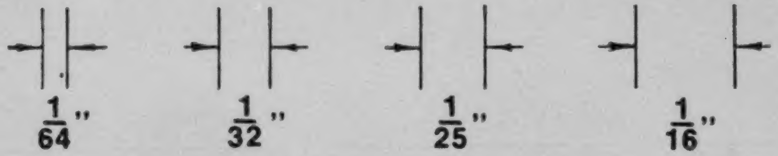
Lo cual es igual, exactament a $\frac{1}{25.4}$
o casi $\frac{1}{25}$ de pulgada

La división más pequeña en la
regla del mecánico en el sistema usual
es $\frac{1}{64}$"

La inmediatamente mayor es $\frac{1}{32}$"

La siguiente, inmeditamente mayor es $\frac{1}{16}$"

Un milímetro es casi la distancia
entre $\frac{1}{32}$" y $\frac{1}{16}$"



(ampliado)

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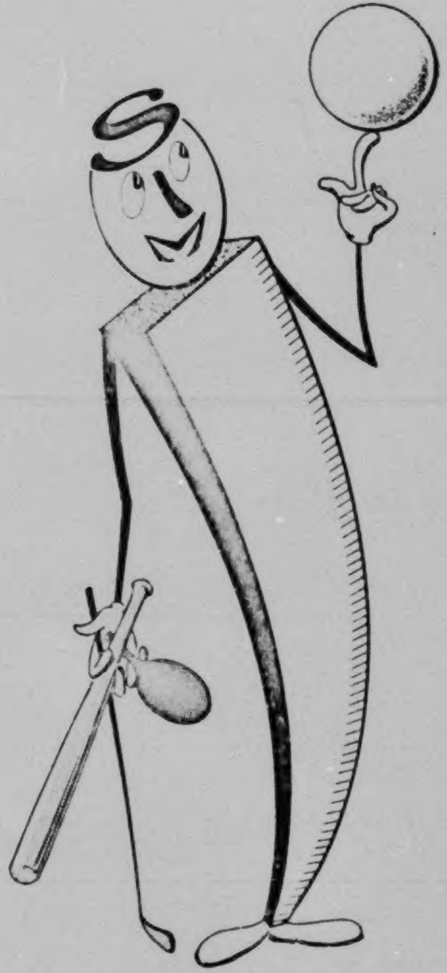
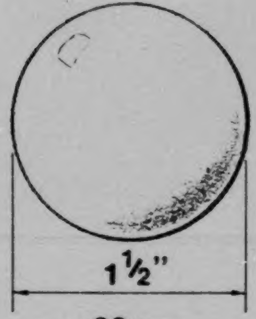
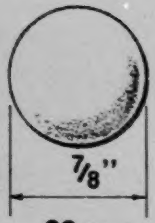
Ahora TOMEMOS UNA PELOTA



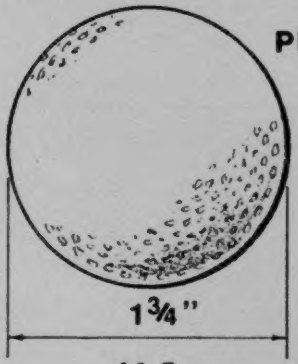
PELOTA DE PING PONG



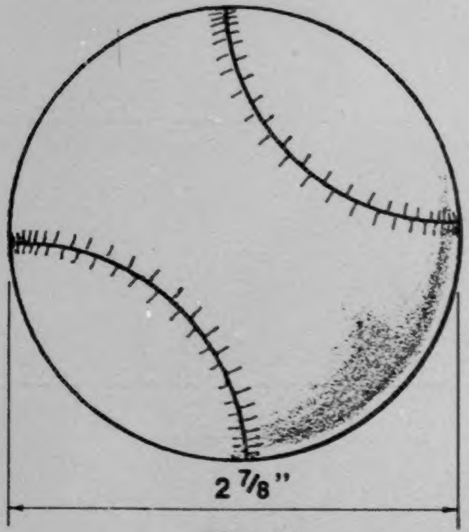
CANICA



PELOTA DE GOLF



BEISBOL



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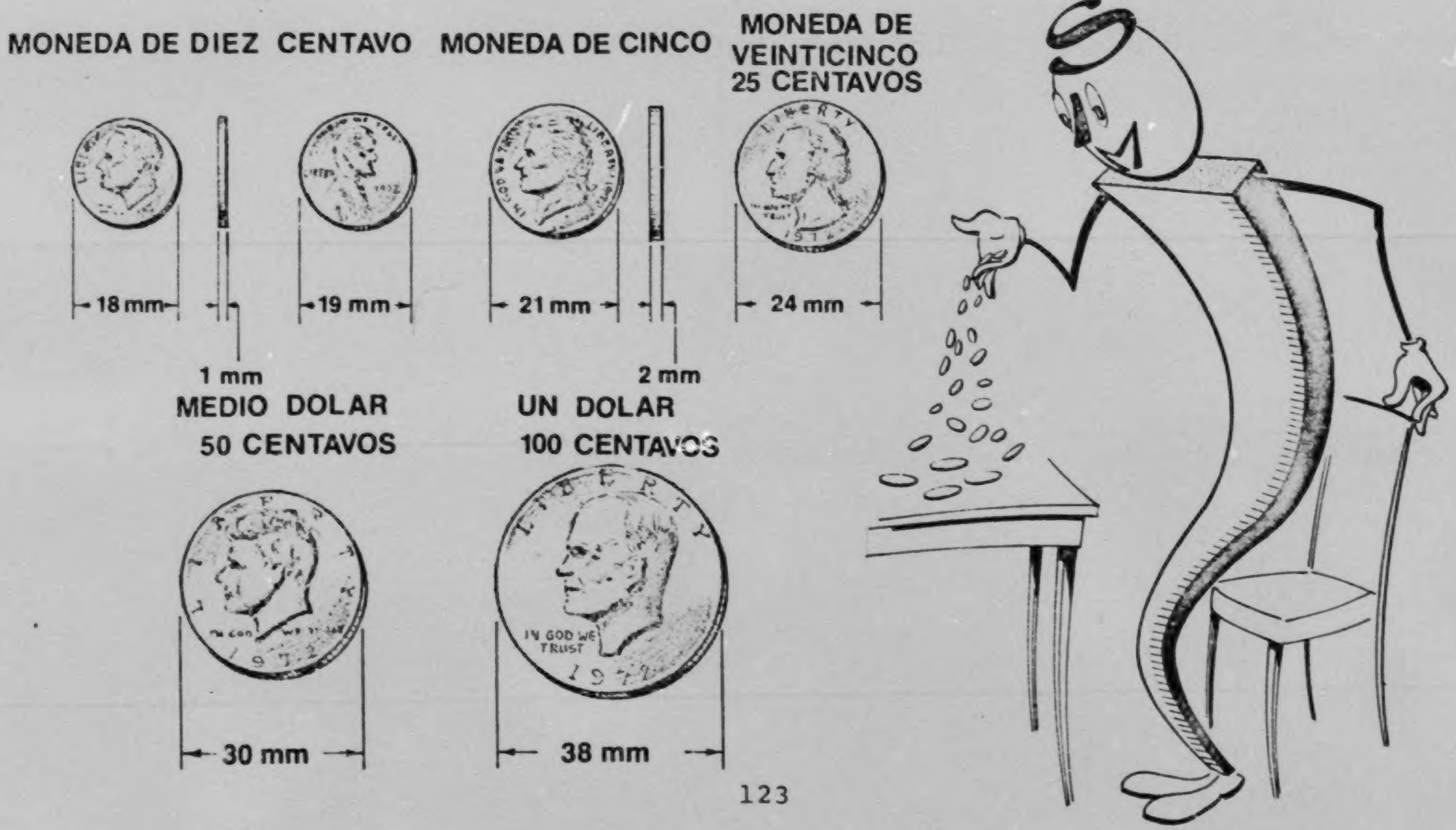
y

EXAMINEMOS SUS MONEDAS.



MONEDA DE DIEZ

CENTAVO

MONEDA DE CINCO

MONEDA DE VEINTICINCO 25 CENTAVOS

18 mm
1 mm
19 mm
21 mm
2 mm
24 mm

MEDIO DOLAR 50 CENTAVOS

UN DOLAR 100 CENTAVOS

30 mm
38 mm

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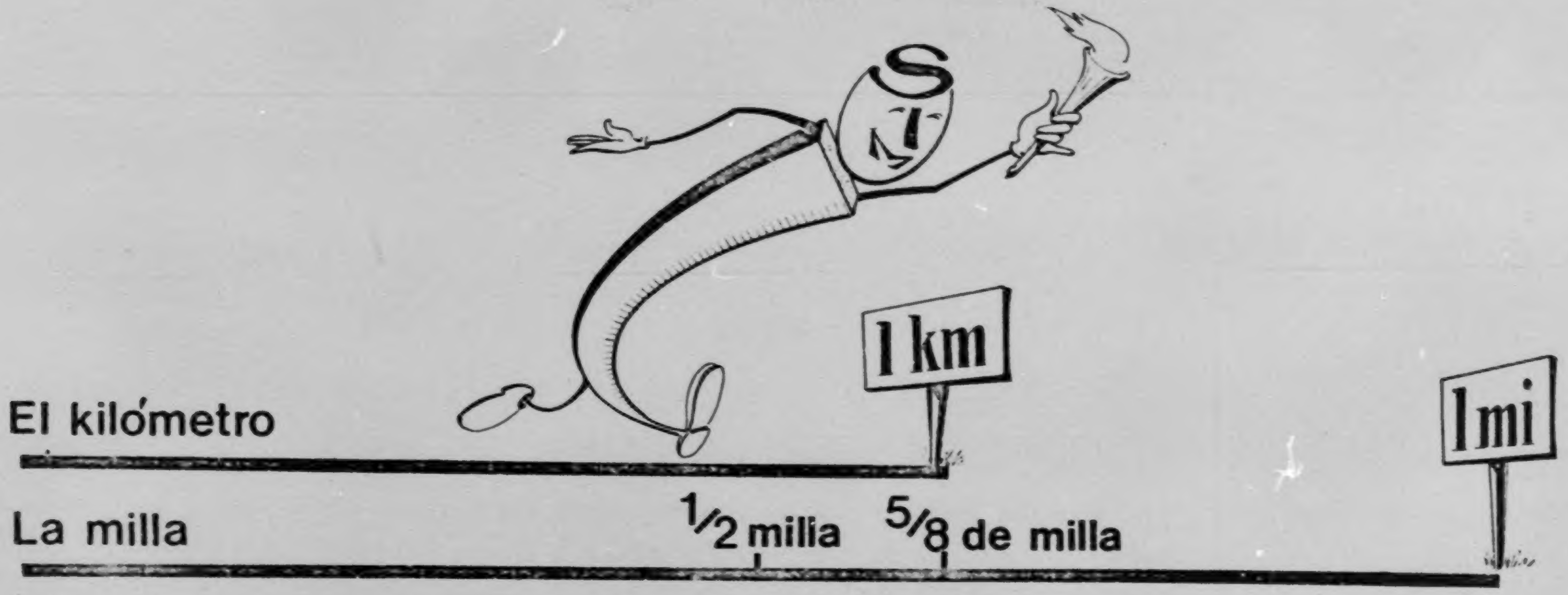
Un kilómetro

-se usa para distancias largas.

1000 metros igualan a un kilómetro (km).

Un kilómetro es casi 5/8 de milla.



El kilómetro

La milla

1/2 milla

5/8 de milla

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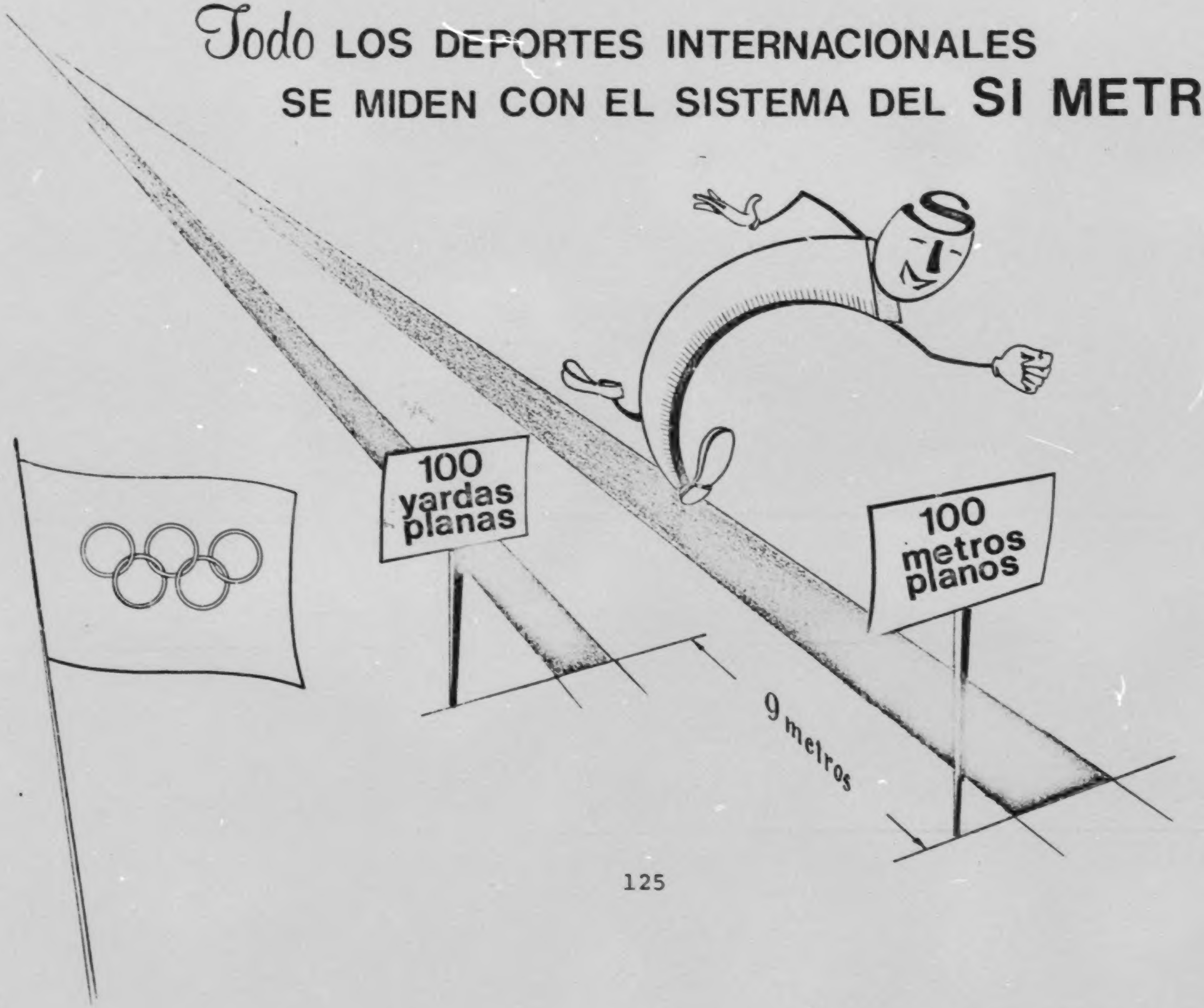
Todo LOS DEPORTES INTERNACIONALES SE MIDEN CON EL SISTEMA DEL SI METRICO


100 yardas planas
100 metros planos
9 metros

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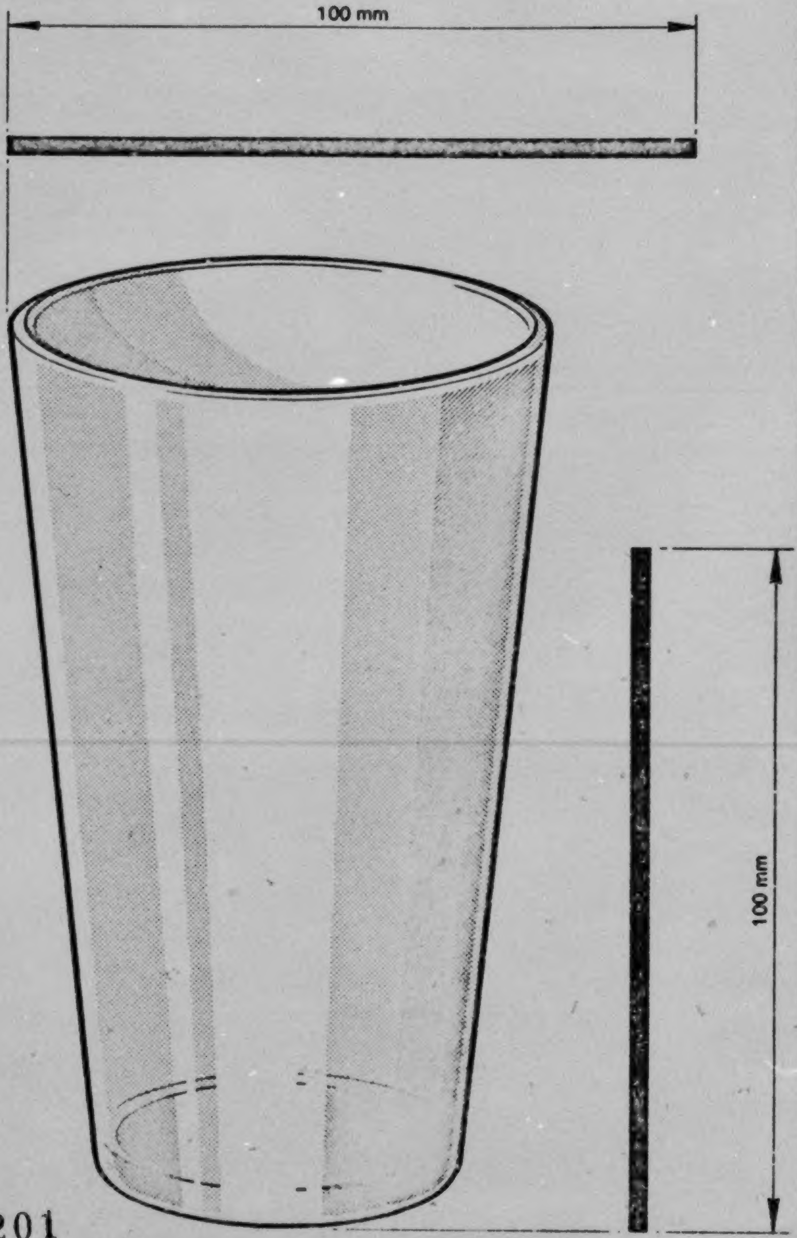
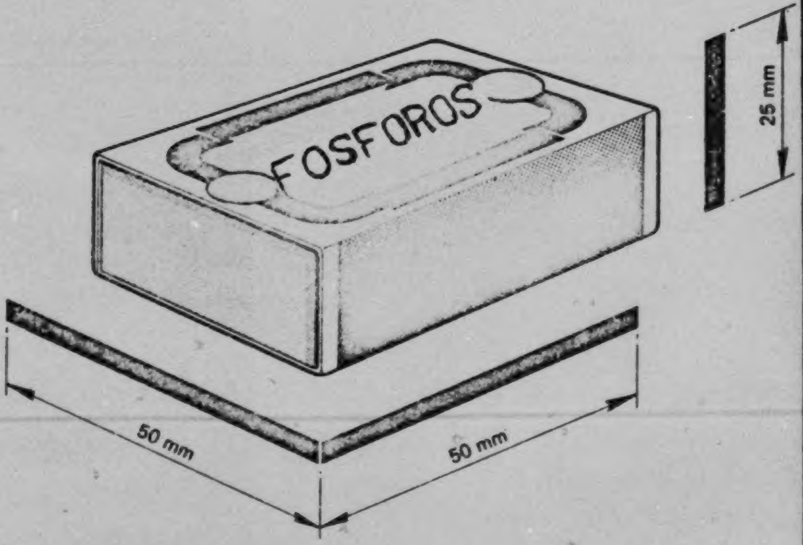

100 mm
100 mm

201


FOSFOROS
25 mm
50 mm
50 mm

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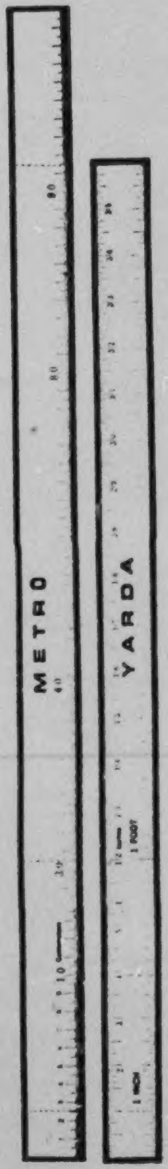
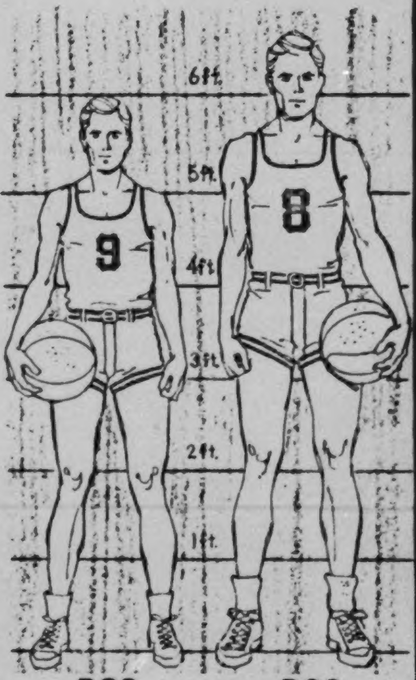

METRO
YARDA
1 FOOT
1 INCH


6ft.
5ft.
4ft.
3ft.
2ft.
1ft.
9
8

DOS YARDAS DE ALTURA **DOS METROS DE ALTURA**

Conozca AL HERMANO kilogramo (kg)

la unidad básica de masa

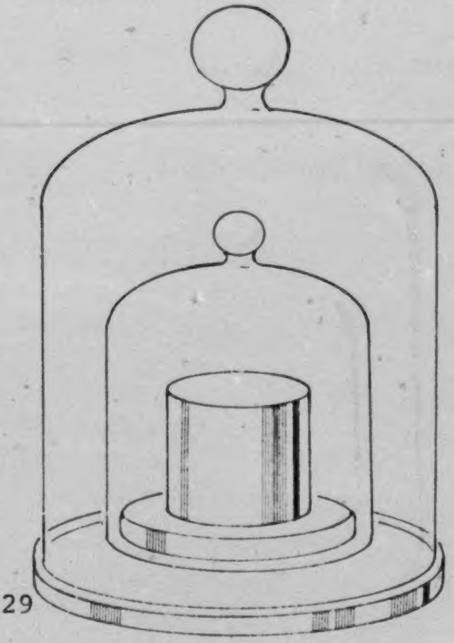
Definición científica:

El patrón de masa es un cilindro hecho de la aleación de platino-iridio, guardado por la oficina Internacional de Pesos y Medidas en París.

Un prototipo, duplicado en los EE. UU., el Kilogramo No. 20, se custodia en la Oficina Nacional de patrones.

El Kilogramo es la única unidad básica que emplea el prefijo kilo.

El gramo es muy pequeño para usos prácticos.



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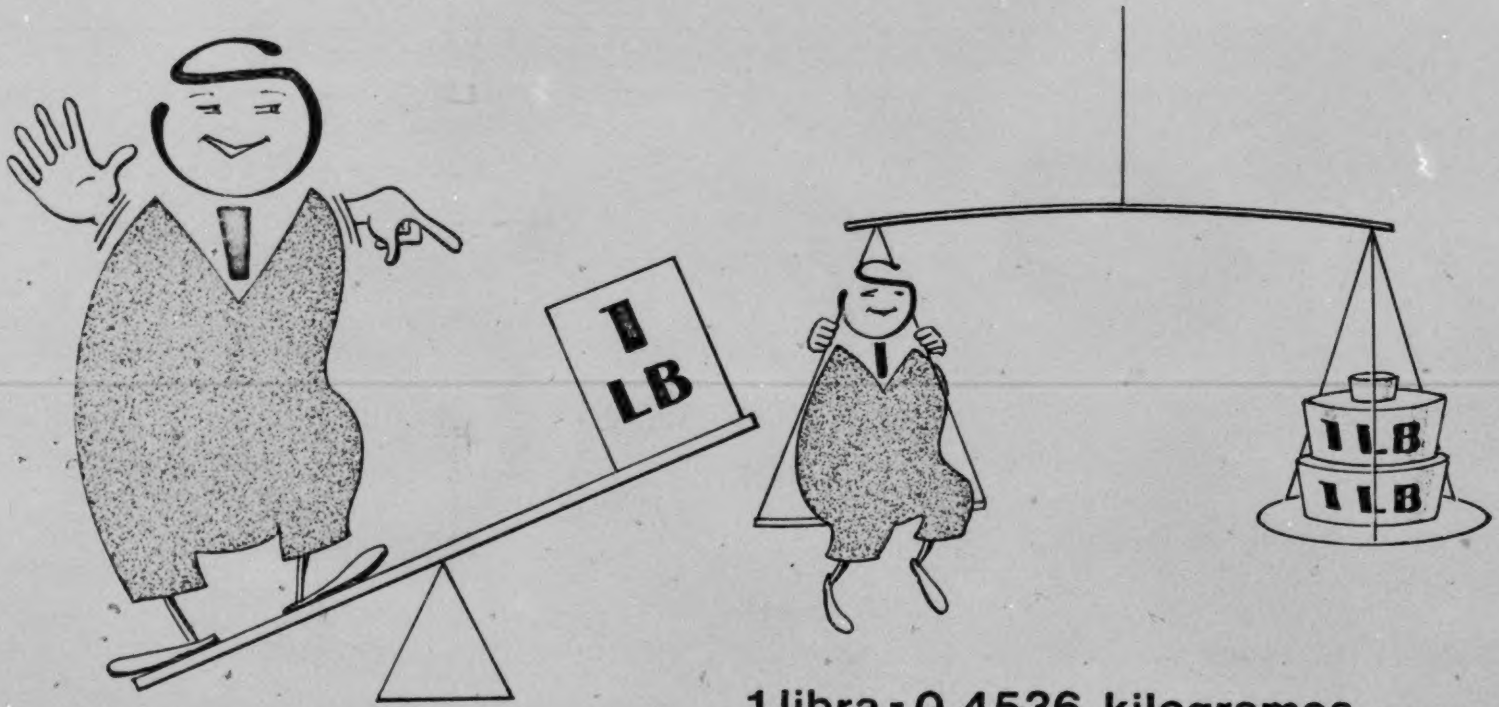
YO SOY EL HERMANO KILOGRAMO

soy mucho más pesado
que una libra

Peso alrededor de
2.2 libras.



1 libra = 0.4536 kilogramos
1 kilogramo = 2.2046 libras

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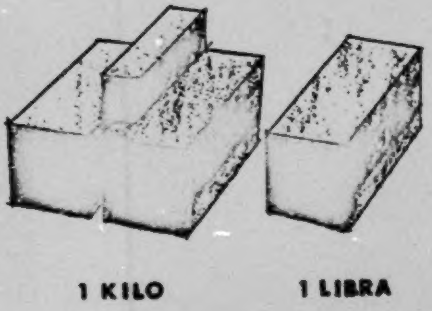
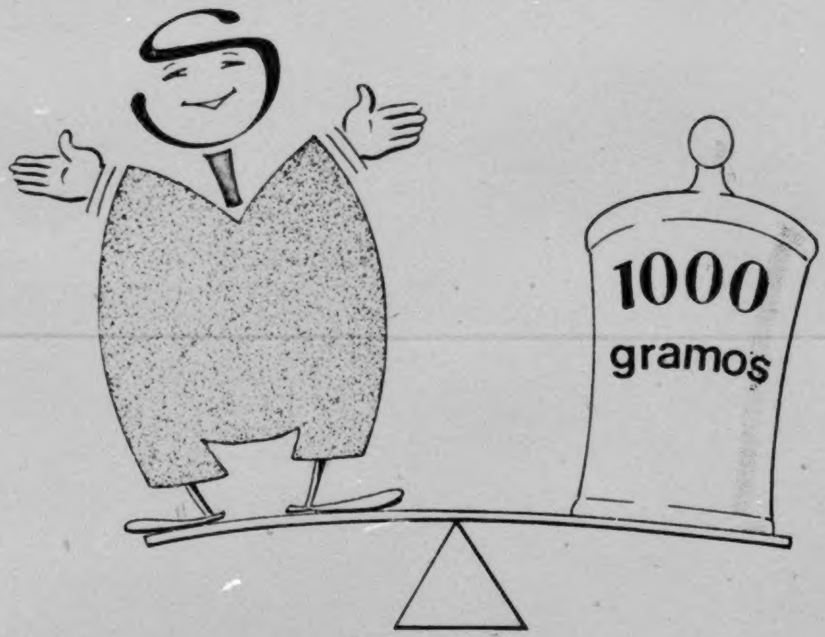
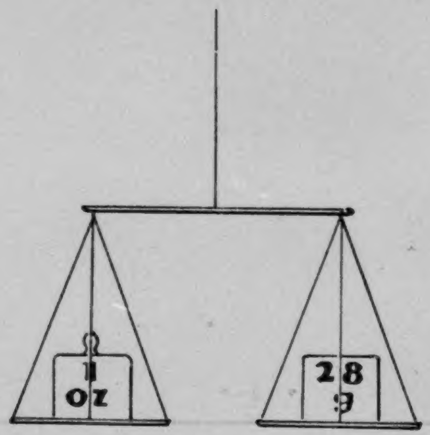

1 KILO
1 LIBRA

1 Kilogramo = 2.204 Libras

Un kilogramo (kg)
pesa
1000 gramos (g)



Una onza pesa
casi 28 gramos



1 onza = 28.35 gramos

1 gramo = 0.03527 onzas

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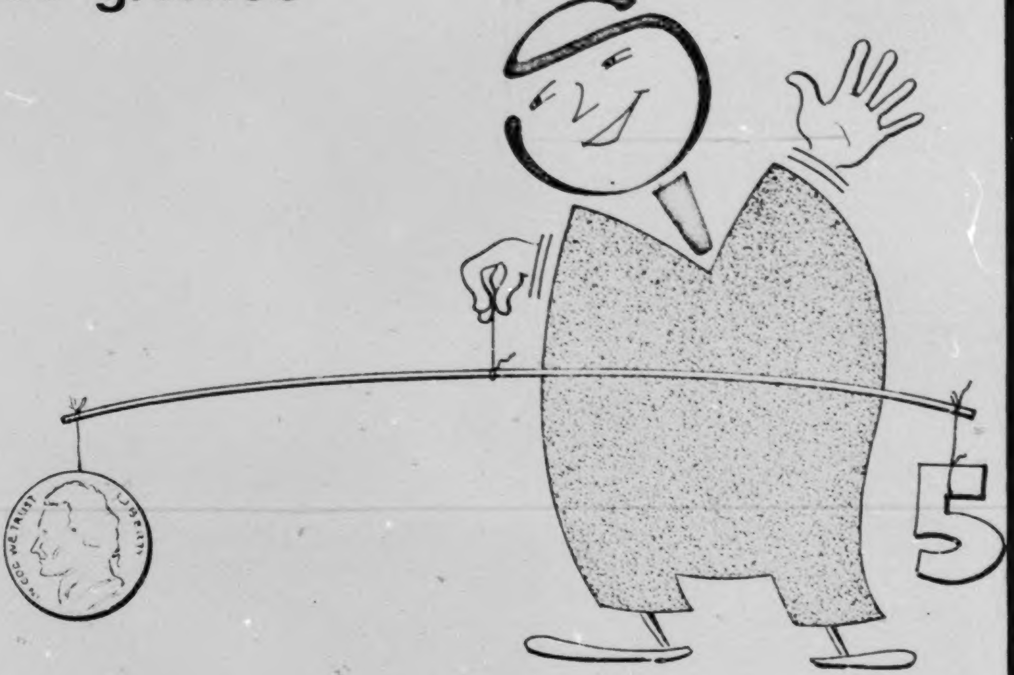
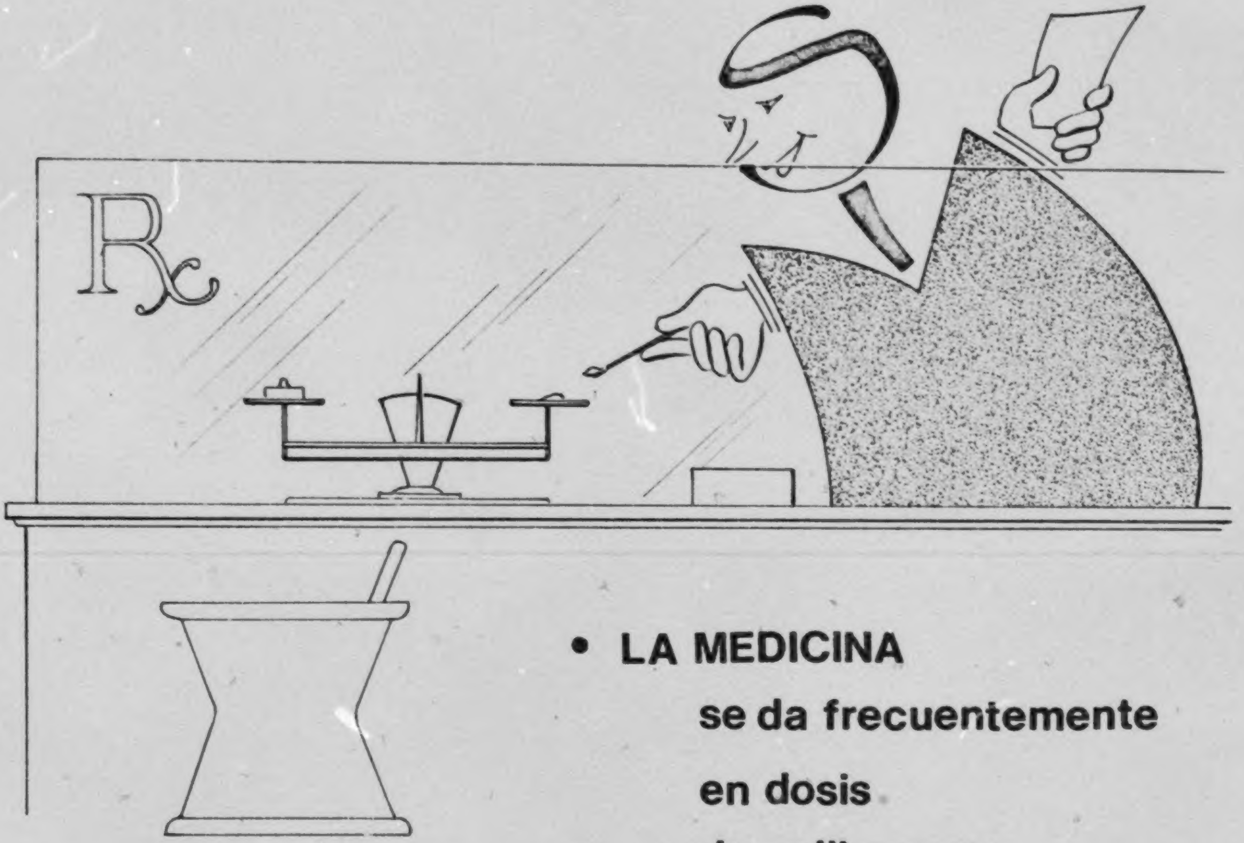
UNA MONEDA DE CINCO

pesa casi
cinco gramos


IN GOD WE TRUST
LIBERTY
5

Para pesos muy pequeños se usa el miligramo (mg).

1 miligramo = 0.001 gramo



- **LA MEDICINA**
  se da frecuentemente
  en dosis
  de miligramos.

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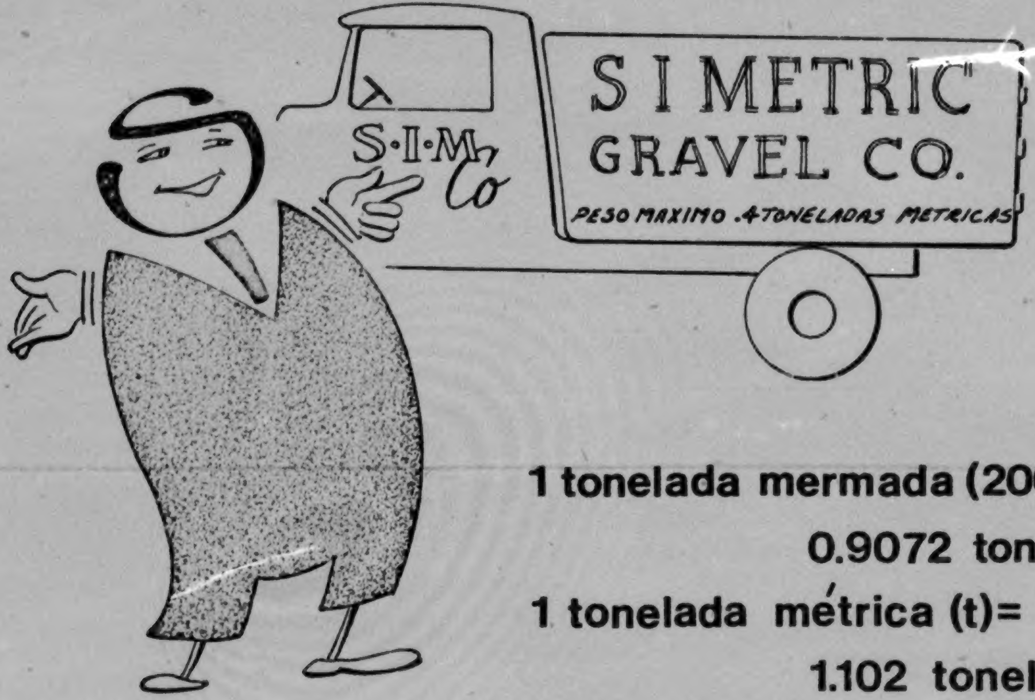
GRANT NO. O EG-0-72-1868

Para pesos más grandes–

se usa la tonelada métrica (t).
1 tonelada métrica = 1000 kilogramos
o casi 2200 libras.


S I METRIC
GRAVEL CO.
PESO MAXIMO 4 TONELADAS METRICAS
S·I·M Co

1 tonelada mermada (2000 lbs) =
0.9072 toneladas métricas
1 tonelada métrica (t) =
1.102 toneladas mermadas.

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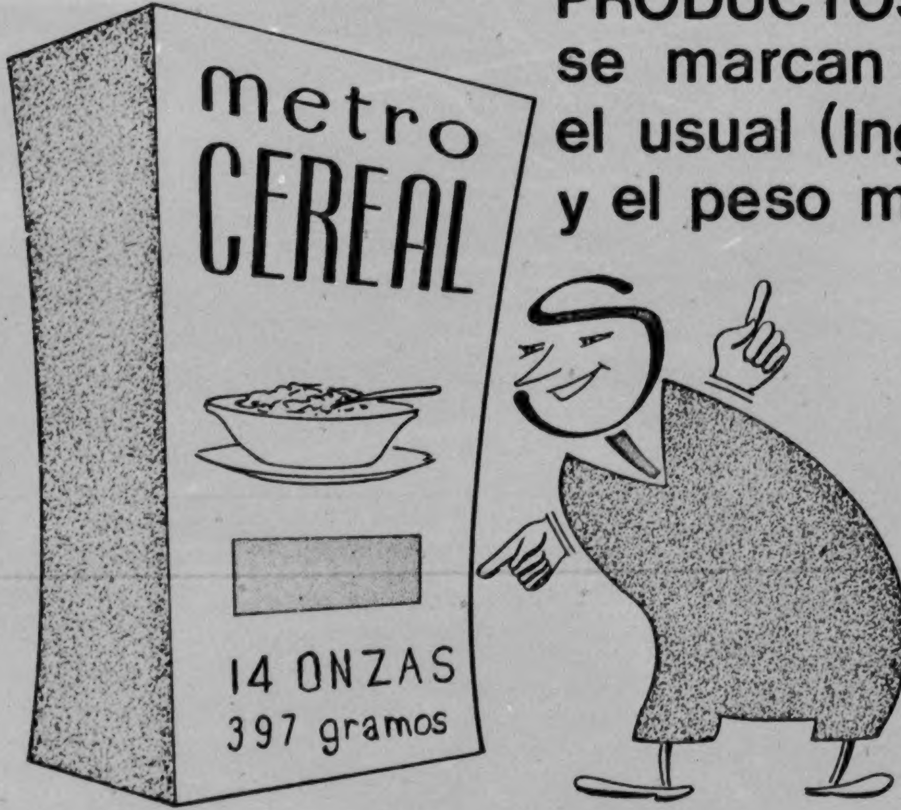
GRANT NO. O EG-0-72-1868

Muchos COMESTIBLES Y
PRODUCTOS CASEROS
se marcan con los dos sistemas:
el usual (Inglés)
y el peso métrico.


metro
CEREAL
14 ONZAS
397 gramos

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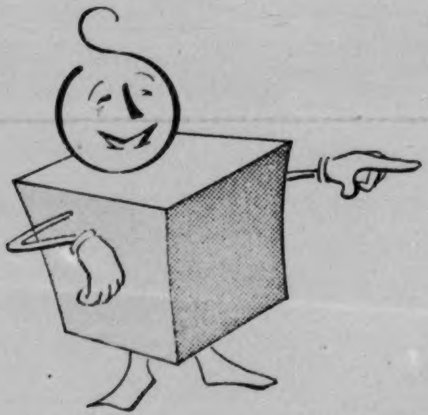
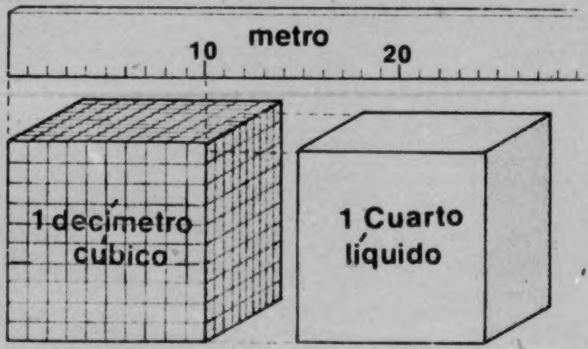
GRANT NO. O EG-0-72-1868

Conozca al PRIMO HERMANO Litro

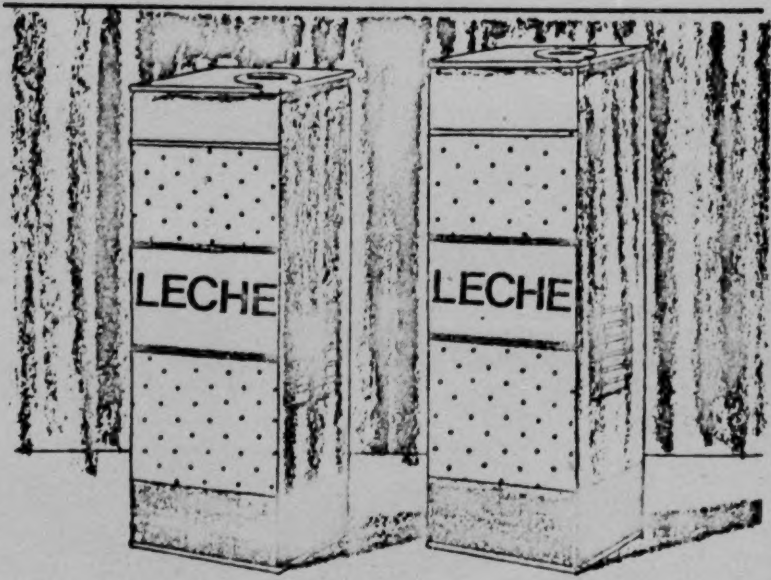
la unidad derivada de volumen.

El litro es igual a un decímetro cúbico (1dm^3)
o a 1000 centímetros cúbicos (1000cm^3)
o a 1000 000 milímetros cúbicos. (1000 000 mm)
El litro se usa para medir líquidos tales como agua,
leche, pintura, aceite y muchos más.
El litro tiene un poquito más (casi 6%) que un cuarto.





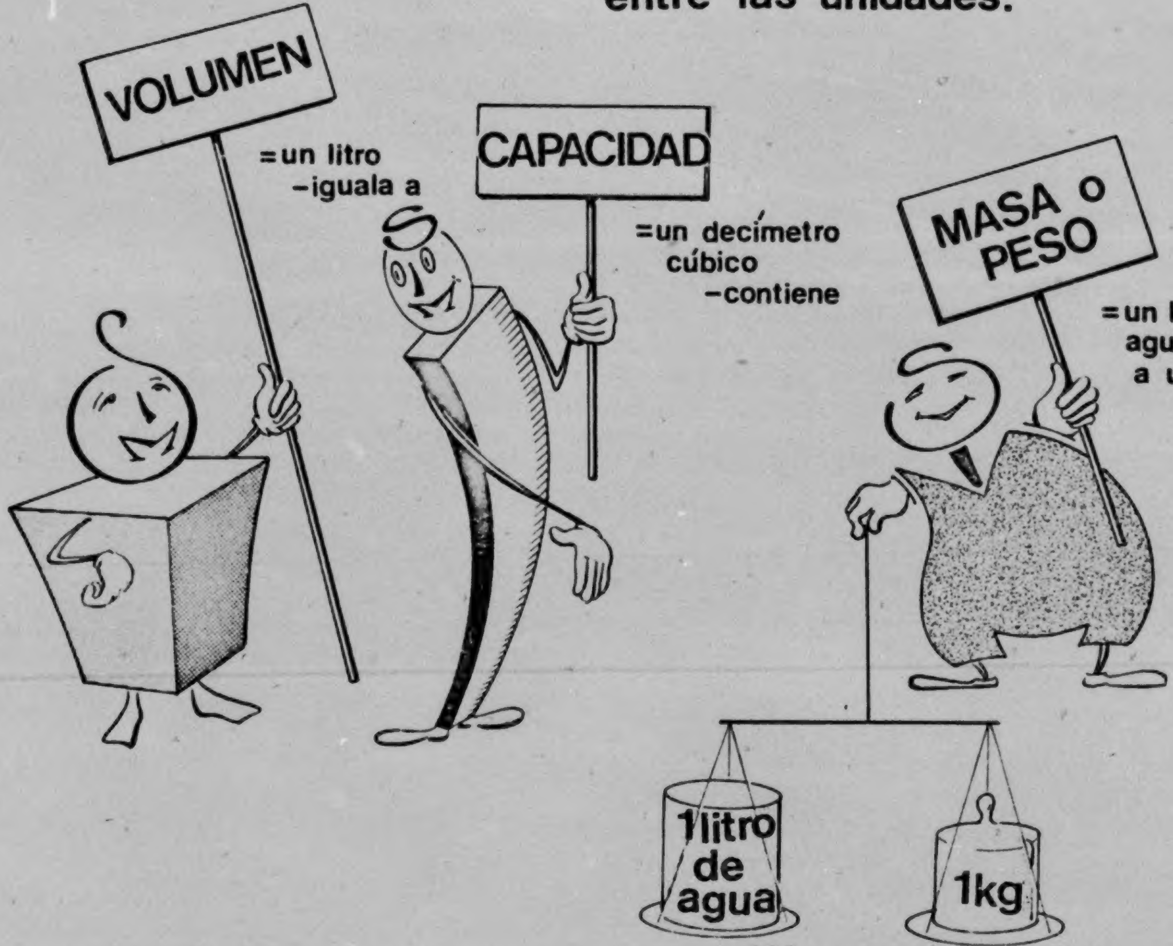
USOE SPONSORED PROJECT NO. V257006
GRANT NO. O EG-0-72-1868



1 CUARTO 1 LITRO

1 LITRO = 1.057 CUARTOS LIQUIDOS

En en el sistema métrico hay una relación definitiva entre las unidades.


VOLUMEN
CAPACIDAD
MASA O PESO
1litro de agua
1kg

=un litro
-iguala a

=un decímetro
cúbico
-contiene

=un kilogramo de
agua pura destilada
a una temperatura
de 4°C.

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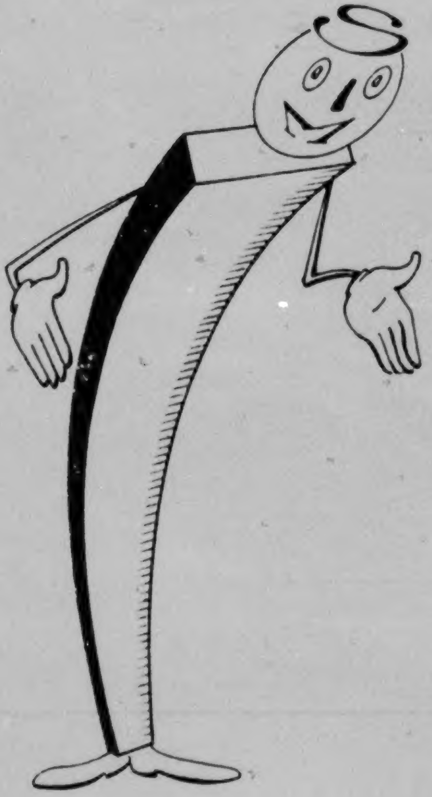
GRANT NO. O EG-0-72-1868

CENTER FOR METRIC EDUCATION • WESTERN MICHIGAN UNIVERSITY

TRES MEDIDAS PARA RECORDAR



EL metro
es un poco más largo
que una yarda—
—39.37 pulgadas.

EL litro
es un poco más grande
que un cuarto
—casi 6%

EL kilogramo
es un poco más
que dos libras
—2.2 libras

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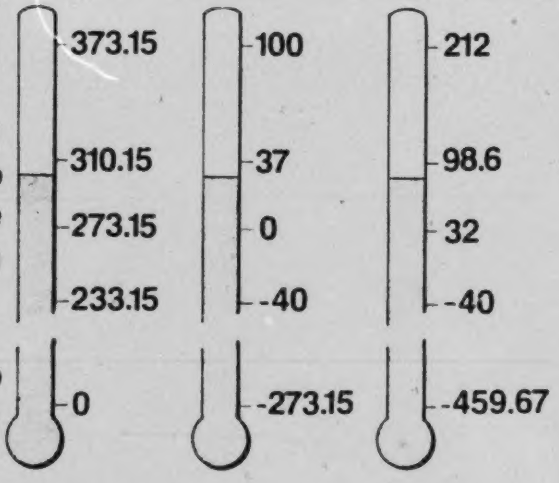
GRANT NO. O EG-0-72-1868

CENTER FOR METRIC EDUCATION • WESTERN MICHIGAN UNIVERSITY

Conozca al HERMAN Celsio
la unidad de temperatura.

En el sistema métrico, los científicos usan la unidad básica oficial kelvin (k) para medir temperaturas:
Sin embargo, la escala del Celsio se usa Para necesidades diaras.
La escala Celsio se deriva de la escala del Kelvin

y ambos están relacionados por la diferencia exacta de 273.15 grados.



	KELVIN	CELSIO	FAHRENHEIT
Punto de ebullición del agua	373.15	100	212
temperatura normal del cuerpo humano	310.15	37	98.6
el agua se congela a	273.15	0	32
	233.15	-40	-40
cero absoluto	0	-273.15	-459.67

Temp. K = Temperatura °C + 273.15

Temp. °C = $\frac{\text{Temp. F} - 32}{1.8}$

Temp. F = 1.8 (Temp. °C) + 32

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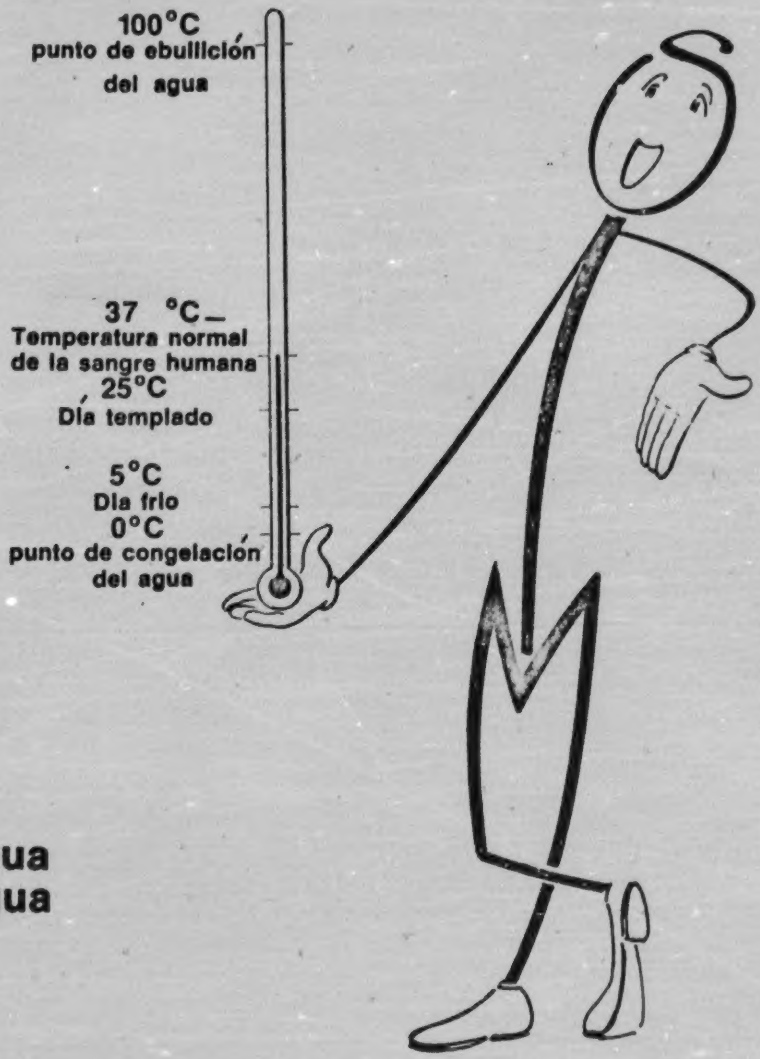
EL HERMANO Celsio
LA TEMPERATURA

La unidad métrica común para temperatura es el grado Celsio. Este es idéntico al grado Centígrado.

El símbolo es °C

Dos temperaturas de común referencia son
- 100 °C punto de ebullición del agua
- 0°C punto de congelación del agua


100°C
punto de ebullición del agua
37 °C
Temperatura normal de la sangre humana
25°C
Día templado
5°C
Día frío
0°C
punto de congelación del agua

227

228

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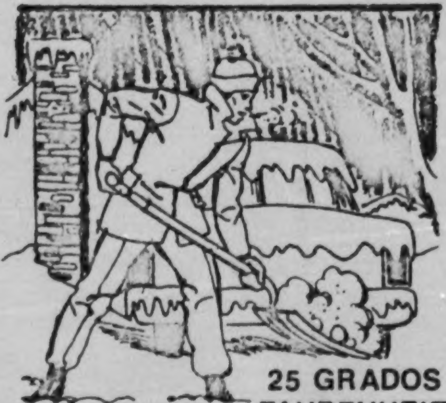
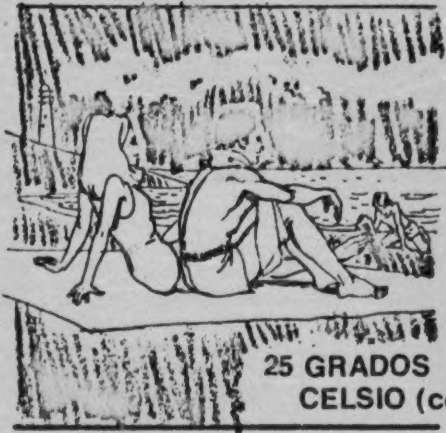
GRANT NO. O EG-0-72-1868

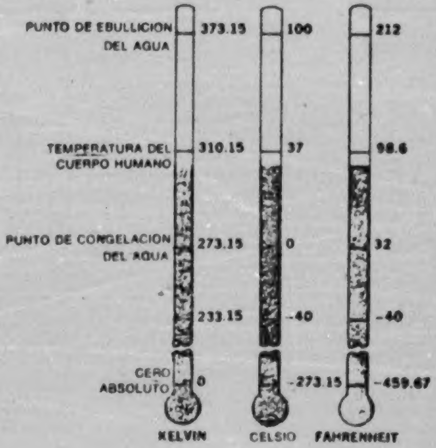
CENTER FOR METRIC EDUCATION • WESTERN MICHIGAN UNIVERSITY



25 GRADOS FAHRENHEIT



25 GRADOS CELSIO (centígrados)

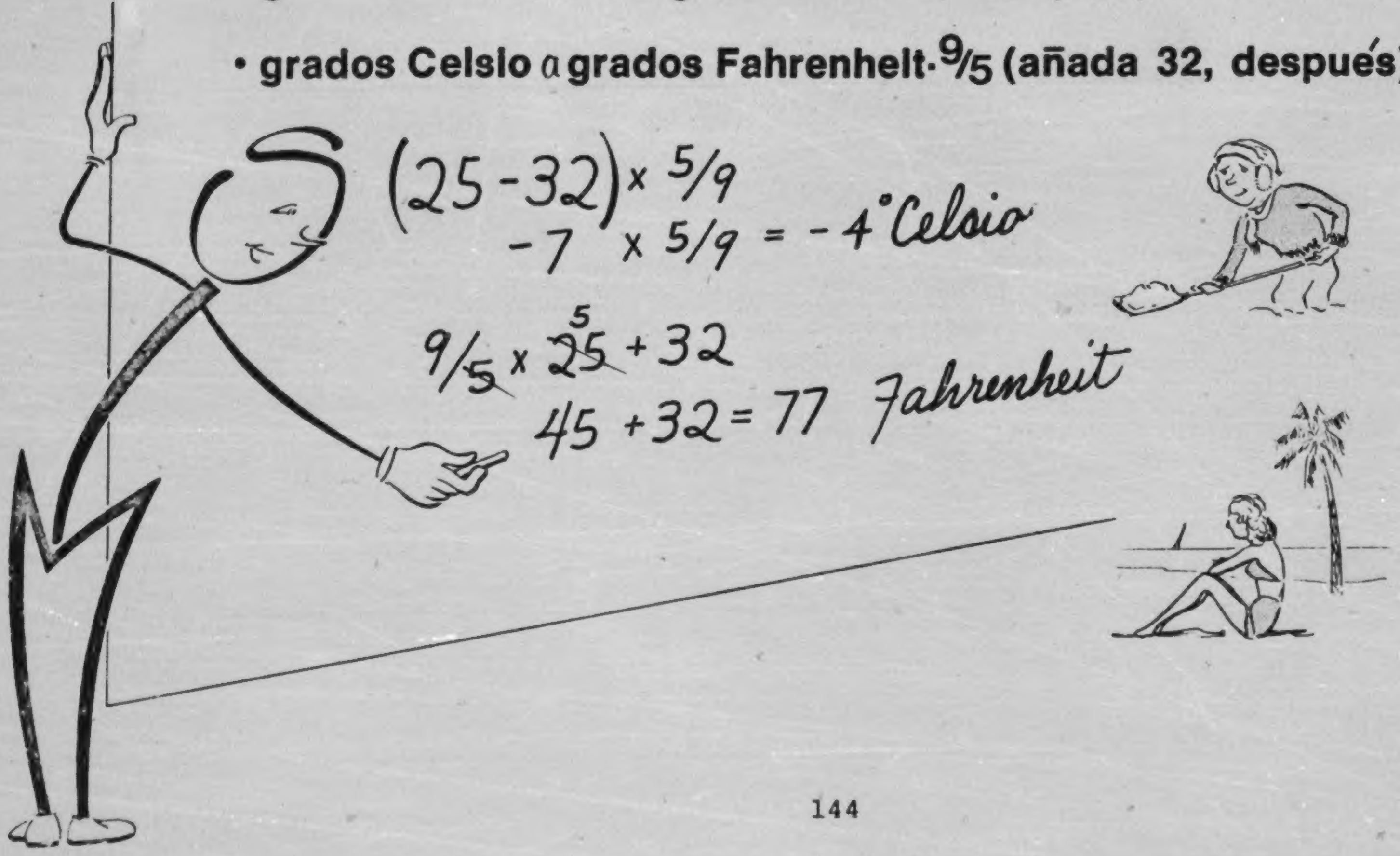

PUNTO DE EBULLICION DEL AGUA
373.15
100
212
TEMPERATURA DEL CUERPO HUMANO
310.15
37
98.6
PUNTO DE CONGELACION DEL AGUA
273.15
0
32
233.15
-40
-40
CERO ABSOLUTO
0
-273.15
-459.67
KELVIN
CELSIO
FAHRENHEIT

USOE SPONS
GRA

LA TEMPERATURA

La conversión aproximada del sistema usual al métrico-y vice versa:

- **grados Fahrenheit a grados Celsio · 5/9 (después de substraer 32)**
- **grados Celsio a grados Fahrenheit · 9/5 (añada 32, después)**



$(25-32) \times 5/9$

$-7 \times 5/9 = -4°$ Celsio

$9/\cancel{5} \times \overset{5}{\cancel{25}} + 32$

$45 + 32 = 77$ Fahrenheit

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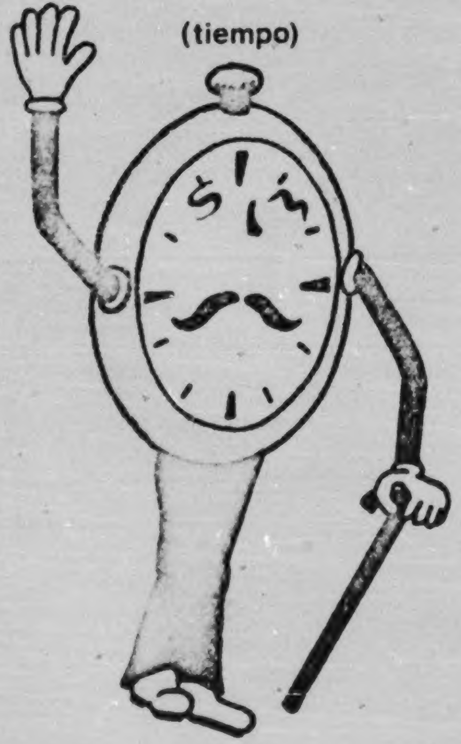
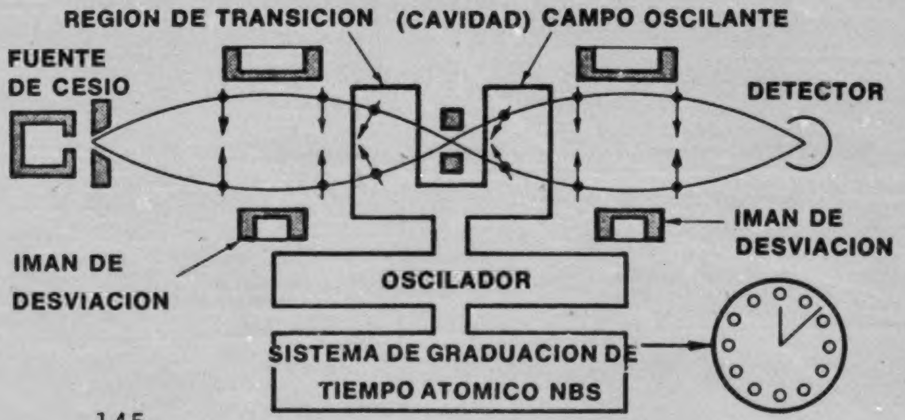
GRANT NO. O EG-0-72-1868

EL HERMANO segundo

(tiempo)



El segundo se define como la duración de 9192 631 770 ciclos de radiación asociada con una transición especifica del átomo celsio a-133. Se efectúa graduando un oscilador a la frecuencia de la resonancia del átomo celsio-133 cuando pasa a través de un sistema de imanes y de una cavidad de resonancia hacia un detector.


REGION DE TRANSICION
(CAVIDAD) CAMPO OSCILANTE
FUENTE DE CESIO
DETECTOR
IMAN DE DESVIACION
IMAN DE DESVIACION
OSCILADOR
SISTEMA DE GRADUACION DE TIEMPO ATOMICO NBS

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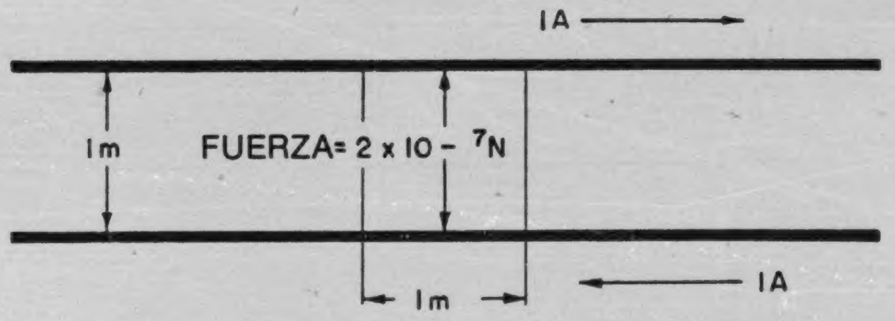
GRANT NO. O EG-0-72-1868

LA HERMANO **Amperio**

(corriente eléctrica)

El amperio se define como la corriente que, si mantenida en cada una de dos cuerdas largas paralelas separadas por un metro en espacio libre, produciría una fuerza entre dos cuerdas (debido a su campo magnético) de 2×10^{-7} newtones por cada metro de longitud.



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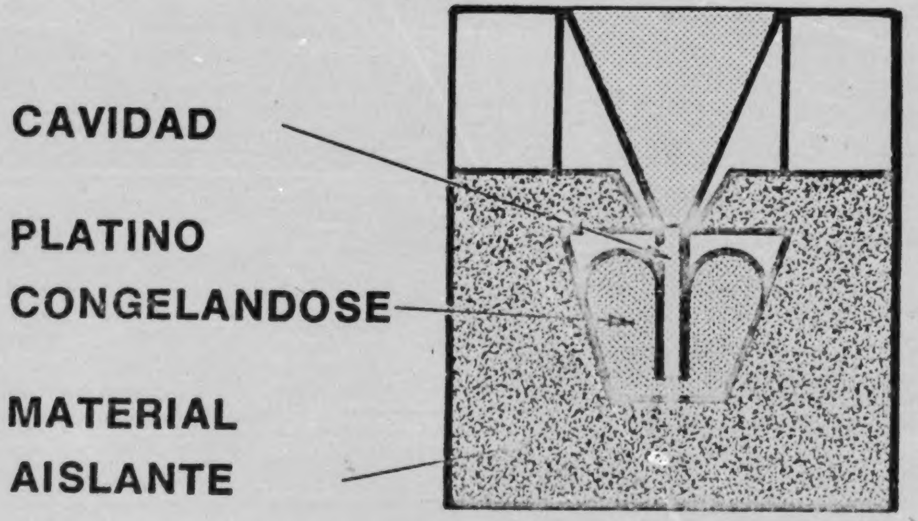
GRANT NO. O EG-0-72-1868

LA HERMANA **candela**

(intensidad luminosa)

La candela se define como la intesidad luminosa de 1/600 000 de un metro cuadrado de un antirradiante (cuerpo negro) a la temperatura de congelación del platino (2045 K).

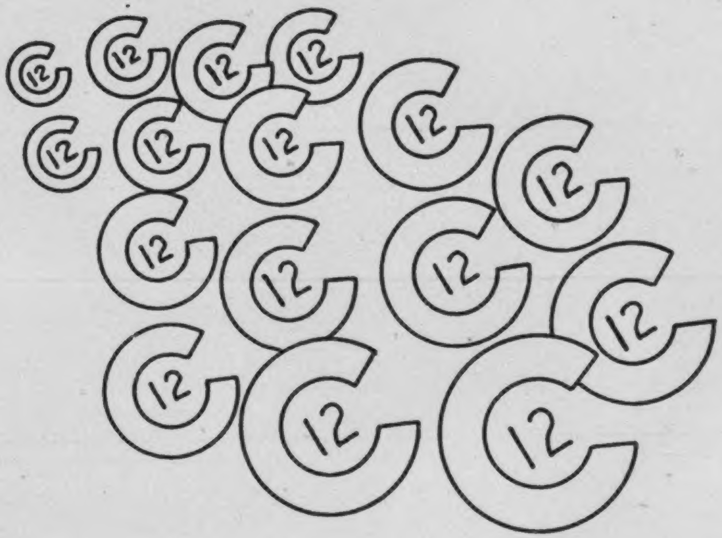

CAVIDAD
PLATINO
CONGELANDOSE
MATERIAL
AISLANTE

USOE SPONSORED PROJECT NO. V257006
GRANT NO. O EG-0-72-1868

LA HERMANA molécula.
(cantidad de
substancia)

238

La molécula es la cantidad de substancia de un sistema que contiene tantas entidades elementales como átomos hay en 0.012 kilogramos de carbón 12.



239

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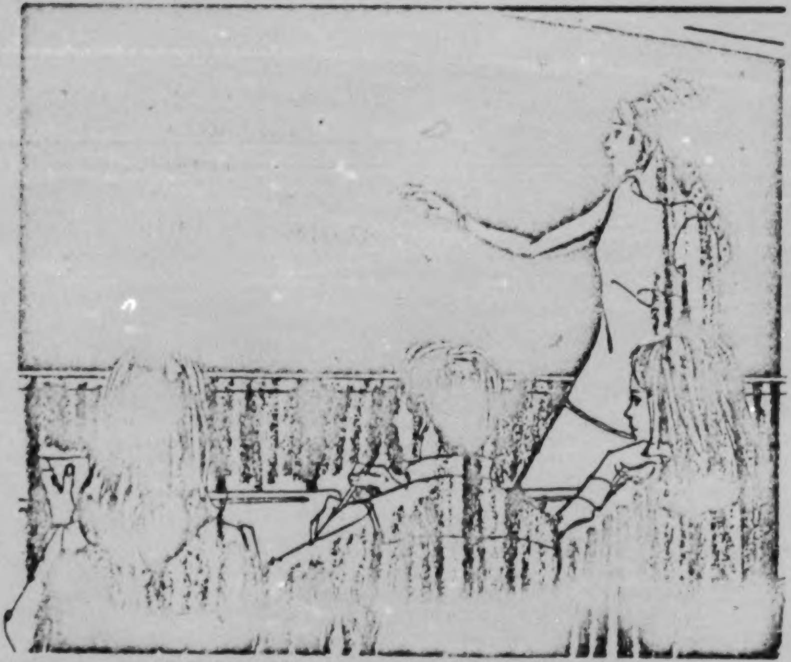
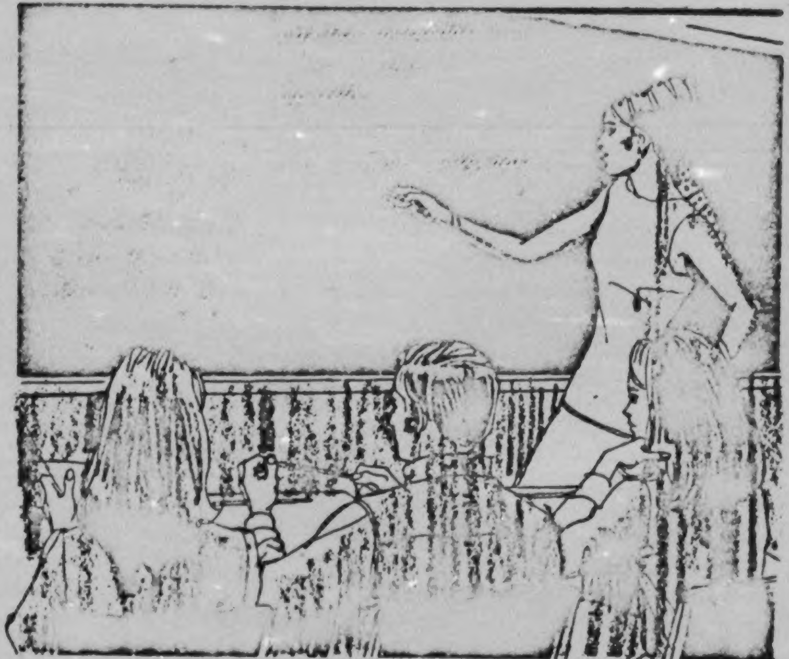
GRANT NO. O EG-0-72-1868



ECUACION METRICA SIMPLIFICADA



ECUACION USUAL DE LOS EE. U.U.

240

241

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GRANT NO. O EG-0-72-1868

CENTER FOR METRIC EDUCATION • WESTERN MICHIGAN UNIVERSITY

LA FANEGA VARIA

150

242

Figure 3-2

CENTER FOR METRIC EDUCATION
WESTERN MICHIGAN UNIVERSITY
KALAMAZOO, MICHIGAN 49008

September 5, 1975

Center for Educational
  Policy and Management
University of Oregon
1472 Kincaid
Eugene, Oregon 97401

Dear Sir:

As part of a federally funded grant entitled Metric Conversion in Vocational Education, we have developed a set of transparency masters for teacing basic metric measurement to Spanish-speaking people. We are anxious to have these materials evaluated in a real-life situation.

If you would have an opportunity to use these materials with students enrolled in vocational programs or adult education, we would be happy to send a set to you providing you will complete our evaluation form.

If you are interested in using these materials, I would appreciate hearing from you.

Sincerely,

John L. Feirer, Director
Center for Metric Education

jer

Figure 3-3

INDIVIDUALS/INSTITUTIONS RECEIVING GOING METRIC FOR CAREER TEACHERS
Spanish Edition

Dr. Melvin Rexroat
Professor of Education
Idaho State University
College of Education
Pocatello, ID 83201

Ms. Maria Guadalupe Tousek
Bilingual Education Service Center
101 North Owen Street
Mount Prospect, IL 60056

Mr. Alexander Tobin
Director
Mathematics Education
School District of Philadelphia
21st Street S. of the Parkway
Philadelphia, PA 19103

Mr. Herbert Siegel
Director
Bureau of Industrial Arts
131 Livingston Street
Brooklyn, NY 11201

Mrs. Myra K. Vachon
Science Department Chairman
Wells Junior High
830 North 19th Street
Milwaukee, WI 53233

Ms. Beatrice M. Woof
Resource Teacher
Fresno Unified Schools
Scandinavian School
3232 N. Sierra Vista
Fresno, CA 93726

American Institute for Research
1791 Arastradero Road
Palo Alto, CA 94302

Mr. Ron Quick
Instructor
Portage Central High
8135 South Westnedge
Portage, MI 49002

Mr. Jamie J. Pena
Adult Basic Education
United Migrants for Opportunity
Kalamazoo, MI 49006

Ms. Gloria S. Cooper
Co-Director
Center for Vocational & Technical Education
Ohio State University
1960 Kenny Road
Columbus, OH 43210

Ms. Eloise Bausch
Instructor
Kalamazoo Central High
2432 North Drake
Kalamazoo, MI 49007

Mr. Carl Hanover, Jr.
Consultant
Industrial Arts Education
105 London Road
Concord, NH 03301

Mrs. Barbara Walker
Science Coordinator
Washington International School
2735 Olive Street, N.W.
Washington, D.C. 20007

Ms. Jane Zion
Memorial Elementary
Hollis Street
Framingham, MA 01701

Mr. Phillip S. Paris
Director
Multicultural Education Division
Northwest Regional Educational
  Laboratory
Lindsay Building
710 S. W. Second Avenue
Portland, OR 97204

Figure 3-4

EVALUATION OF METRIC KITS

Institution United Migrants for Opportunity

Name of Instructor Jamie J. Pena

Name of Kit Going Metric for Career Teachers

Is the material practical for your class situation? Most of it

What are the outstanding features of the material? The fact it was also produced in Spanish. That helps tremendously.

Are any masters especially helpful or unique? Why? Those dealing with length, weight, volume and temperature. They are simple and self-explanatory.

What could have made the material more useful to you? Since this is as new to me as it is to the student, actual classroom instruction to teach teachers the system could be very helpful.

What additional material would you like to see in the kits? Perhaps a conversion table for each unit. For example: (N-inches x 25.4 = N millimetres) (N feet x 30 = N centimetres)

Do you have any statistical data that would indicate the effectiveness of these kits? _____ Yes __xx__ No

If yes, please indicate. ____________

General Critique (150 words - use reverse side of sheet)

Because of the short time I had to work with the material, it makes it difficult to effectively evaluate it. Once I have the completed kit and am able to implement it in my next program in June, I'll be able to more thoroughly evaluate its effectiveness.

Overall, the material seems adequate. Perhaps CT 40, 41, 42 and 43 could be simplified some more if possible. Since the average grade level of my students is elementary, material used to instruct them must be as simple and self-explanatory as possible.

Also, since the metric system is new and strange to the majority of the general public, its importance to everyday life must be shown because one of the most asked questions is, "Why do I have to learn this?" Perhaps that could somehow be added to the kit. Maybe a film would be more effective than transparencies. I'll be able to give you more once I use it in a comple thirty-week program.

EVALUATION OF METRIC KITS

Institution Junior High School 52M

Name of Instructor Verdi Avila

Name of Kit Going Metric for Career Teachers

Is the material practical for your class situation? Yes

What are the outstanding features of the material? Use of maps, illustrations, attempt to make material interesting.

Are any masters especially helpful or unique? Why? Yes. Drawings are easy to understand.

What could have made the material more useful to you? Reduce or eliminate printed material on some charts

What additional material would you like to see in the kits? More photographs or drawings of actual metric measuring devices, tapes, scales, metric cube.

Do you have any statistical data that would indicate the effectiveness of these kits? ____ Yes xx No

If yes, please indicate.

General Critique (150 words - use reverse side of sheet)

EVALUATION OF METRIC KITS

Institution Kalamazoo Central High School

Name of Instructor E. Bausch, K. Hunter

Name of Kit Going Metric for Career Teachers

Is the material practical for your class situation? Introductory only

What are the outstanding features of the material? Illustrations, repetition of many words.

Are any masters especially helpful or unique? Why? Numbers 13, 14 & 15 Comparison with the system students are accustomed to.

What could have made the material more useful to you? Present each unit of measurement separately--on different days--not so much at one time; exercises to reinforce material.

What additional material would you like to see in the kits? Summary chart of equivalents; exercise sheets

Do you have any statistical data that would indicate the effectiveness of these kits? ____ Yes xx No

If yes, please indicate.

General Critique (150 words - use reverse side of sheet)

By just presenting the materials as such (transparencies and script) the student is confused because he knows neither the metric system or Spanish well. It should be presented over a number of consecutive days and very slowly so that the student has a chance to absorb both the new Spanish vocabulary and the metric system.

Transparency number 44 is not clear.

It might be a good idea to provide some practical conversions of the sort a student might have to make. For example, buying fabric, weighing himself, buying food.

There are some misspelled words on the transparencies.

Board of Education of the City of New York

Bureau of Industrial Arts

131 LIVINGSTON STREET, BROOKLYN, N. Y. 11201

TEL. 596-5057

HERBERT SIEGEL, Director

March 24, 1976

Dr. John L. Feirer, Director
Center for Metric Education
Western Michigan University
Kalamazoo, Michigan 49008

Dear John:

Thank you for the opportunity to review the Spanish edition of "Going Metric in Career Education".

We requested this material to be evaluated by a bilingual Spanish speaking teacher, one who is familiar with the metric system. He is a native of South America.

He has indicated that this material is useful and has introduced some parts of it in the shop classes.

Below are some comments and questions he forwarded together with the evaluation form.

1. There is some difficulty in conveying the idea that there is currently two metric systems. One national the other internation SI.
2. It is necessary to use odd fractions of an inch in showing metric units together with common units i.e. La division mas pequena en mi es?
3. If we identify Fahrenheit and Kelvin with this type of spelling, why is Celsius spelled as Celsio?
4. On the chart identified as Conazea al Herman Celsio, should not an "O" be added to the word Herman?

If additional copies of this material is available, we would appreciate receiving 25 copies for distribution to those schools where bilingual programs are now in effect.

We look forward to greeting you at the next convention, in Iowa.

Regards.

Sincerely,

Herb Siegel

HERBERT SIEGEL
Director

HS:NF:pl

THE CENTER FOR VOCATIONAL EDUCATION
The Ohio State University • 1960 Kenny Road • Columbus, Ohio 43210
Tel: (614) 486-3655 Cable: CTVOCEDOSU/Columbus, Ohio

February 18, 1976

John L. Feirer, Director
Center for Metric Education
Western Michigan University
Kalamazoo, MI 49008

Dear John:

Unfortunately your Spanish metric materials arrived too late to be evaluated by two Puerto Rican educators who were at The Center on sabbatical. A Mexican-American vocational teacher joined The Center more recently and he agreed to evaluate your package. His comments were as follows:

1) The language used is formal and too sophisticated for use by the average person speaking in conversational Spanish. The package, therefore, will need to be adapted to specific localities before it can be taught.

2) He felt the use of the term "El Hermano" would be received as patronizing by the spanish speaking community. This would included the term "Conozca al hermano metro".

3) SI METRICO would be confusing in spanish because "si" is already a spanish word. Therefore, "si" should be spelled "S.I."

4) He felt that many of the terms were literal translations from english rather than a spanish rendition of the concept; for example, "iman de desviacion" and felt that these would not be understood. Another example "monedas de diaz" is a very formal expression for "dime" and is not in common usage.

This reviewer is a vocational teacher from San Antonio, Texas and was looking at the materials from his perspective as a Skills Center teacher. He felt that your materials would be more appropriate for college level students.

Since you were aware of the language problem in your introduction to the materials, I am not sure this is very helpful to you.

Best wishes,

Gloria S Cooper

GC:bjd

Reviewed by the American Institute for Research

GOING METRIC FOR CAREER TEACHERS - SPANISH

Comments:

Note to user:

It would be less controversial to say that "This instructional material has been prepared in as standard a Spanish..." etc., rather than "as pure a Spanish..." since people are sensitive about which Spanish is more "pure".

#3. typographical error -- frabajo should be trabajo

#7. What level is this for? This page is very advanced; the next page talks about the Metric Family, Brothers and Sisters, etc.

#8. This page is confusing. It lists 5 brothers, 2 sisters, 1 cousin above illustrations which do not correspond.

#18. The notes talk about the thickness of coins, but the chart shows diameter.

#21. This sounds like a Zen question: "What is the size of a glass with water?" (Shouldn't it be "vaso de agua" at any rate?) The chart doesn't show the actual measurement, either.

THROUGHOUT -- I would prefer "estándar" to "patrón" for "standard" or "model", since patrón has two meanings and this makes charts like #24 confusing. (The more common meaning of patron is landlord or sponsor.)

#26. I think it will bother Spanish speaking people to tell them that it is incorrect to say kilo for kilogram, when everyone in Mexico and S. America does so.

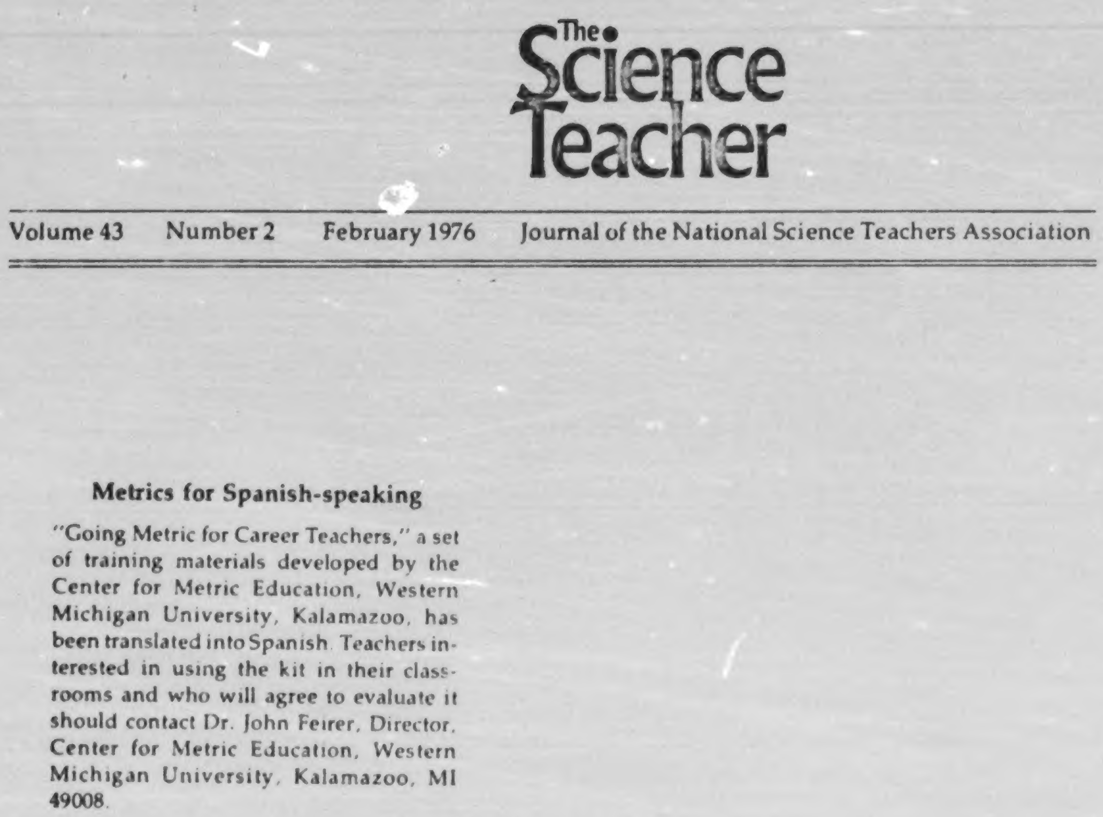
#36. typo - Para should be para (no cap.)

#40, 41, 42. Very difficult to understand

Where does the picture of bushel baskets go?

DFR

Figure 3-5



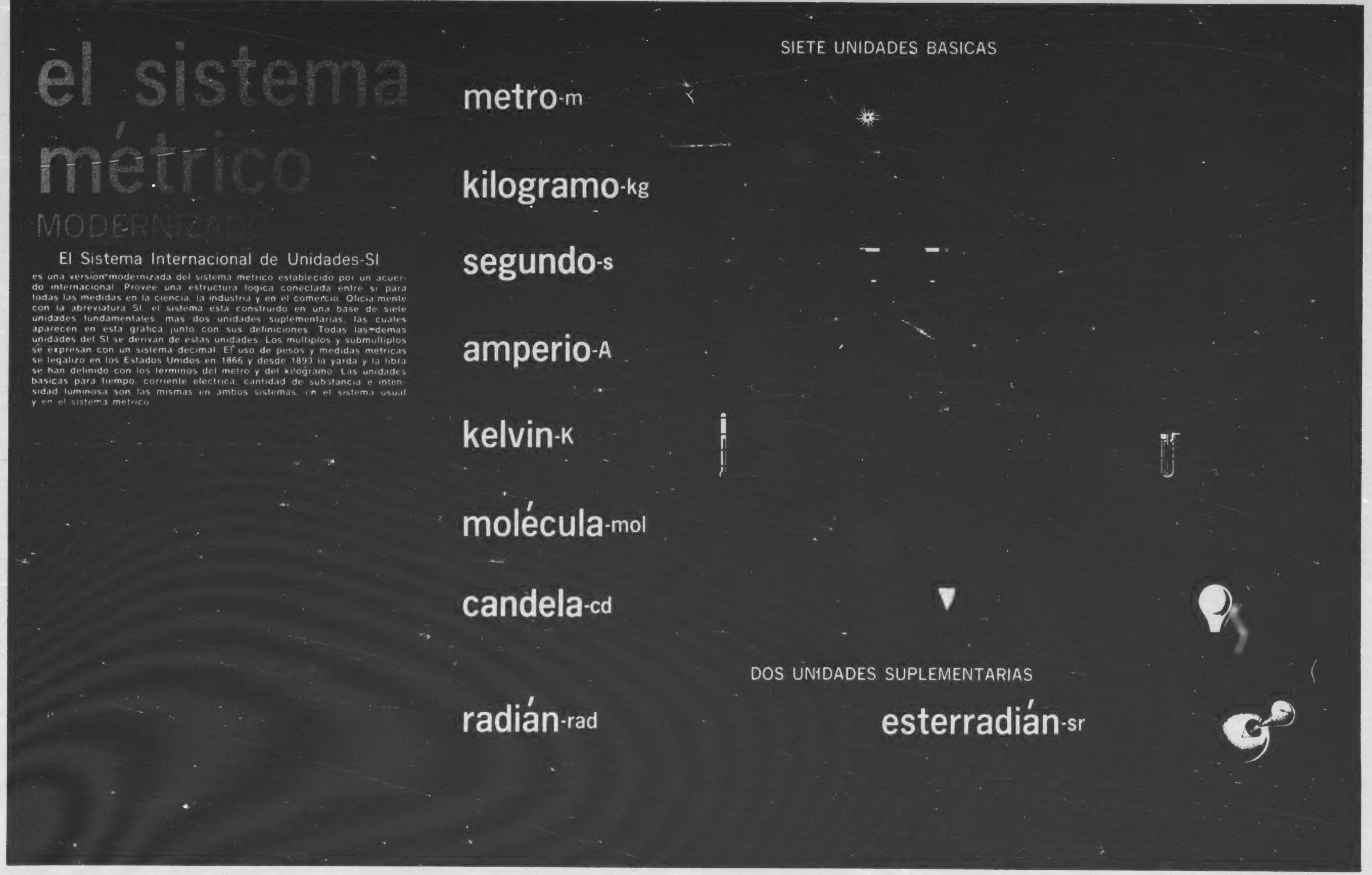
The Science Teacher

Volume 43 Number 2 February 1976 Journal of the National Science Teachers Association

Metrics for Spanish-speaking

"Going Metric for Career Teachers," a set of training materials developed by the Center for Metric Education, Western Michigan University, Kalamazoo, has been translated into Spanish. Teachers interested in using the kit in their classrooms and who will agree to evaluate it should contact Dr. John Feirer, Director, Center for Metric Education, Western Michigan University, Kalamazoo, MI 49008.

Figure 3-6



el sistema métrico

MODERNIZADO

El Sistema Internacional de Unidades-SI

es una version modernizada del sistema metrico establecido por un acuerdo internacional. Provee una estructura logica conectada entre si para todas las medidas en la ciencia, la industria y en el comercio. Oficialmente con la abreviatura SI, el sistema esta construido en una base de siete unidades fundamentales mas dos unidades suplementarias, las cuales aparecen en esta grafica junto con sus definiciones. Todas las demas unidades del SI se derivan de estas unidades. Los multiplos y submultiplos se expresan con un sistema decimal. El uso de pesos y medidas metricas se legalizo en los Estados Unidos en 1866 y desde 1893 la yarda y la libra se han definido con los terminos del metro y del kilogramo. Las unidades basicas para tiempo, corriente electrica, cantidad de substancia e intensidad luminosa son las mismas en ambos sistemas, en el sistema usual y en el sistema metrico.

SIETE UNIDADES BASICAS

metro-m

kilogramo-kg

segundo-s

amperio-A

kelvin-K

molécula-mol

candela-cd

DOS UNIDADES SUPLEMENTARIAS

radián-rad

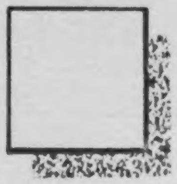
esterradián-sr

Figure 3-7

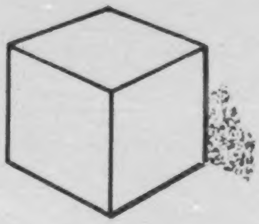
El SISTEMA METRICO para USO DE LA VIDA DIARIA

Longitud: metro - m

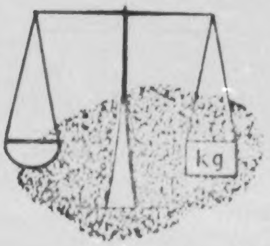
Area: Metro cuadrado - m^2



Volumen: metro cúbico - m^3

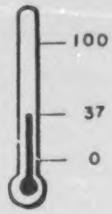


Peso: Kilogramo - kg

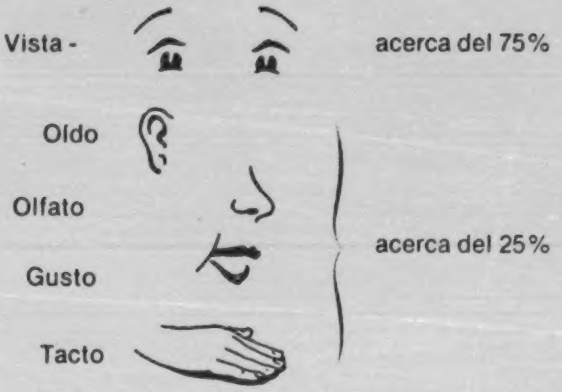


Volumen Líquido: litro - ℓ o l

Temperatura:
grado Celsio - °C



Aprendemos por nuestros sentidos:


Vista -
acerca del 75%
Oido
Olfato
Gusto
Tacto
acerca del 25%

Aprendemos por: ensayo y error

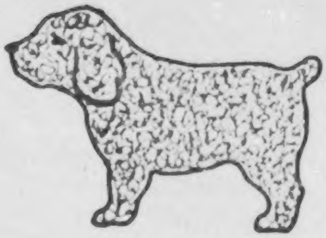
observación

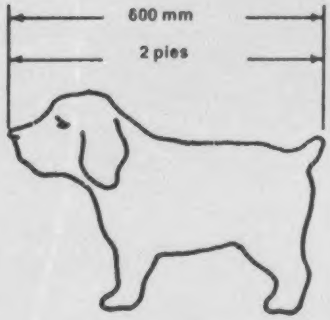
hecho

Las observaciones son lo uno o lo otro: "cualitativas" o "cuantitativas".

Por ejemplo: **Cualitativa** - El perro es suave.

Cuantitativa - El perro tiene dos pies de largo.




600 mm
2 pies

Qué es medir? Medir es encontrar el tamaño, cantidad o suma de cosas.

Medida es un sistema o forma de medir con unidades. Es hacer observaciones "cuantitivas" usando algunas unidades "patrones".

Cualquier cosa puede usarse como "patrón" de medida.

grano de cebada

pie humano

No muy exacta.

barra de metal

Completamente exacta.

Longitud de honda de luz

Muy exacta.

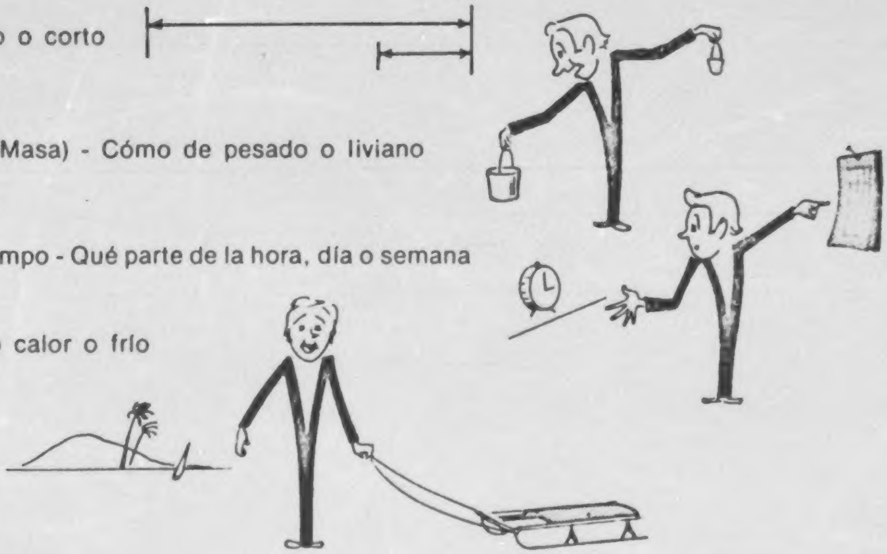
Algunas cosas que medimos:

Longitud - Cuánto de largo o corto

Peso (Masa) - Cómo de pesado o liviano

Tiempo - Qué parte de la hora, día o semana

Temperatura - Cuánto calor o frío



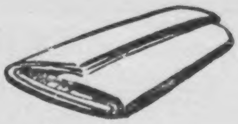
Durante todo el día usted está tomando medidas.

El sonido del reloj despertador en la mañana para despertarlo - **hora** - son las 7:30 a.m.

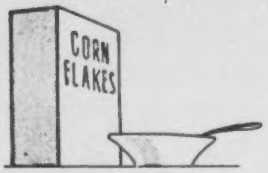
Usted se levanta y se para en la báscula de baño - su **peso** es 70 kilogramos (154 libras).

Mira la temperatura fuera de casa - Es fresca, de 15 grados Celsio (59 grados Fahrenheit).

Camina a la puerta a recoger el periódico de la mañana - una distancia de 10 metros (33 pies).



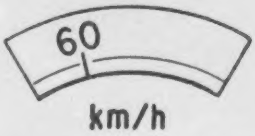
Entonces está listo para el desayuno. Se saca una caja de cereal - de Tamaño familiar - el peso está impreso en la carátula del frente, 397 gramos (14 onzas).



Abre la nevera y saca un litro de leche (1.06 cuartos).

MILK
1
LITER

Maneja al trabajo a una velocidad de 60 kilómetros por hora (35 mph).



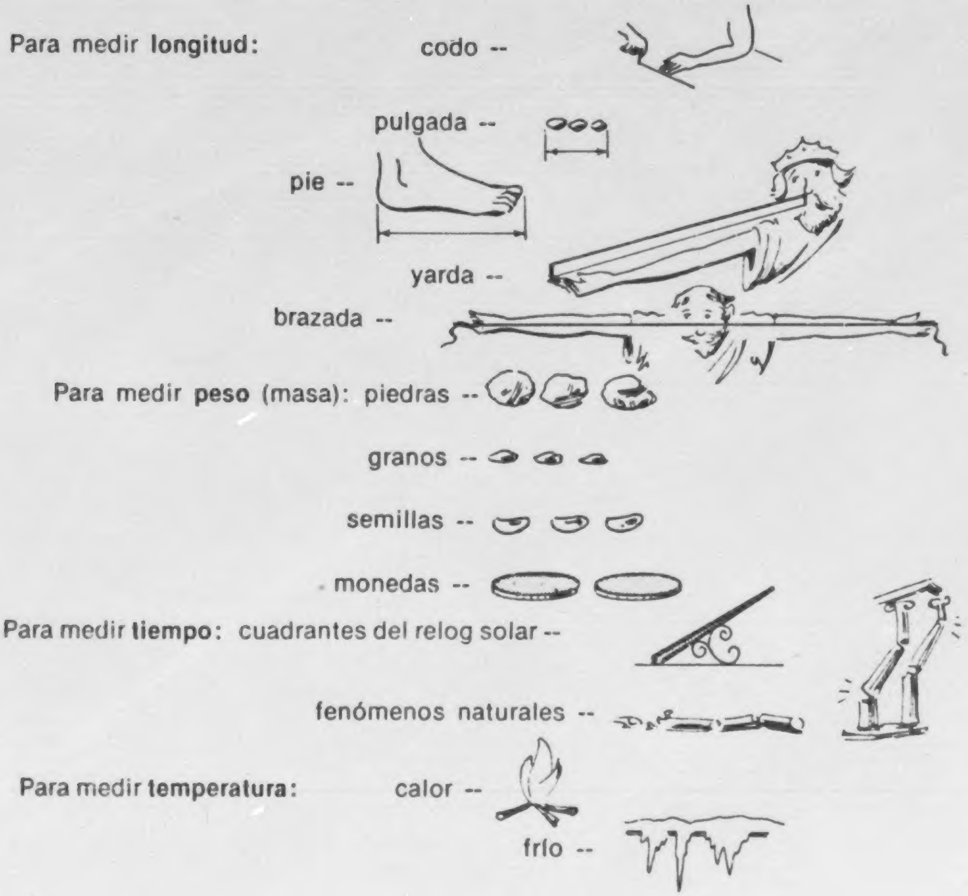
Note el uso del sistema métrico con el del usual (Inglés) equivalente en paréntesis. **La hora** es la misma en los dos sistemas de medidas.

"Los pesos y medidas pueden contarse entre las necesidades de la vida para todo individuo de la sociedad humana. Son necesarias en toda ocupación de la industria humana . . . su conocimiento como uso establecido está dentro de los primeros elementos de la educación y es a menudo aprendido por aquellos que no aprenden nada más, ni siquiera a leer ni a escribir. Este conocimiento se fija en la memoria con su aplicación habitual en las ocupaciones del hombre durante toda la vida."

Presidente John Qunicy Adams
Reporte al congreso sobre conversión
métrica, 1821.

¿Cómo empezaron las medidas? Las primeras civilizaciones se dieron cuenta que necesitaban medir cosas.

Cuando el hombre por primera vez comenzó a hacer medidas, usó las partes de su cuerpo o las cosas naturales a su alrededor como unidades de medida.


Para medir **longitud**:
codo --
pulgada --
pie --
yarda --
brazada --
Para medir **peso** (masa): piedras --
granos --
semillas --
monedas --
Para medir **tiempo**: cuadrantes del relog solar --
fenómenos naturales --
Para medir **temperatura**:
calor --
frío --

Estos patrones de medidas "no muy exactos" formaron la base para más de 80 unidades diferentes en el sistema usual. El sistema usual se llama algunas veces el sistema **Inglés** o el sistema **Pulgada-libra.** En Inglaterra, Canadá, Australia y otros países de habla inglesa se le llama **Sistema Imperial.**

Entre los siglos XIII y XVIII se desarrollaron dos sistemas principales de medidas:

El sistema usual (Inglés) en los Estados Unidos, llamado el sistema Imperial en Inglaterra.

El rey Eduardo I y su sucesor, Eduardo II, establecieron patrones legales con el propósito de comerciar.

Su yarda, una barra metálica, la unidad de longitud, se llamó "ulna de hierro."

El patrón se describió como sigue:

"Y es de recordar que la Ulna de Hierro de nuestro Señor el Rey contiene tres pies y no más y el pie debe contener doce pulgadas, medida con la medida correcta de esta clase de ulna: es decir, una treintaiseisava parte de la dicha ulna forma una pulgada, no más no menos."

Otra definición de la historia antigua:

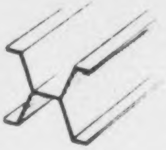
"Se ordena que tres granos de cebada, secos y redondos, formen una pulgada: doce pulgadas formen un pie; tres pies formen una ulna."

Desde un temprano comienzo, se desarrollaron más de 80 patrones de pesos y medidas, la mayoría de ellos sin ton ni son. Por esto el mundo está cambiando al sistema métrico.

El Sistema Métrico

Durante la época de Napoleón, los científicos franceses desarrollaron un sistema más preciso basado en las medidas de la tierra llamado el **sistema métrico.** La unidad básica, el metro fue la diez millonésima parte de la distancia del Polo Norte al ecuador medida sobre usa linea recta que corre a lo largo de la superficie de la tierra pasando por París.

Hubo un pequeño error en esta definición así que más tarde los científicos definieron el metro como la distancia entre dos líneas grabadas sobre una barra especial de platino-iridio. Esta barra se guarda en la Oficina Internacional de Pesos y Medidas cerca de París.



Aún más tarde, el metro se definió en términos de "longitud de onda de luz." Las otras unidades tales como kilogramo para peso y litro para medida de líquido se derivan del metro.

VENTAJAS DEL SISTEMA METRICO

1. Es un sistema decimal basado en unidades de 10, como nuestro dinero.
2. Todos los multiplos y submúltiplos están en la simple pontencia de 10.

Si aprende solamente tres reglas simples del sistema métrico tendrá suficiente conocimiento para usarlo en la vida cotidiana. Las reglas son:

1. El prefijo **mili** significa **una milésima parte** (0.001)
2. El prefijo **centi** significa **una centécima parte** (0.01)
3. El prefijo **kilo** significa **mil veces** (1 000)

Prefijo		Símbolo		Significado
kilo	-	k	x	1 000
hecto	-	h	x	100
deca	-	da	x	10
unidad básica	-	m para metro -		1
deci	-	d		1/10 o 0.1
centi	-	c		1/100 o 0.01
mili	-	m		1/1 000 o 0.001

Cuando se usan estos prefijos con ciertas unidades métricas, los objetos pueden pesarse o medirse de las cantidades más pequeñas a las más grandes. Por ejemplo:

un **milimetro** es una milésima parte del **metro**

un **centímetro** es una centécima parte del **metro**

un **kilómetro** es mil **metros**

un **mililitro** es una milésima parte del **litro**

un **kilolitro** es mil **litros.**

3. Es más fácil de aprender.

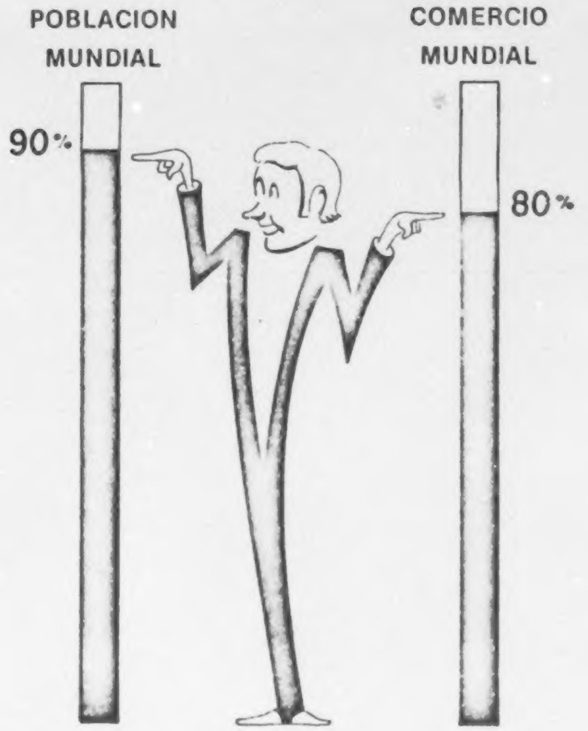
4. Es más fácil de recordar.

5. Hay una relación directa entre las unidades de longitud, superficie, volumen, capacidad líquida y peso.

6. Es el sistema internacional de medidas, aceptado. Se usa la misma terminología en las matemáticas, en la ciencia, en el comercio, en la tecnología y en la vida diaria.

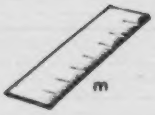
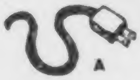
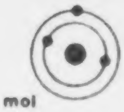
Más del 90 por ciento de la población mundial usa el sistema métrico y más del 80 por cierto del comercio mundial se lleva adelante en el sistema métrico.

He aquí como pronunciar algunos de los términos métricos comunes. Kilómetro se divide en las sílabas "Ki-ló-me-tro" con el acento sobre la segunda sílaba. Se hace énfasis en la segunda sílaba. Pascal, la unidad de presión, se divide en las sílabas "pas-cal" con acento en la última sílaba. Julio. se divide en las síbabas "Ju-lio" y lleva el acento en la primera sílaba. Candela se divide así: "can-de-la" y lleva el acento en la segunda sílaba.



El sistema métrico ha sido refinado y mejorado así que se conoce como SI (sistema modernizado). Este es el sistema que es usado por casi todos los países del mundo.

Comparemos:

	Unidad Básica	**Sistema métrico SI**	**Usual (Inglés) o Sistema Pulgada-Libra**
	Longitud	metre (metro) El deletreo Inglés internacional es metre pero se puede usar meter (metro) para los usos de la vida diaria - m.	pulgada, pie o yarda pg, p, yd
	Peso (masa)	kilogramo - kg	libra - lb
	Temperatura	grados Celsio - °C*	Fahrenheit - °F
		LO MISMO EN AMBOS SISTEMAS	
	Tiempo	segundo - s	segundo - s
	Corriente eléctrica	amperio - A	amperio - A
	Intensidad luminosa	candela - cd	candela - cd
	Cantidad de substancia	molécula - mol	molécula - mol

*Para trabajo científico el kelvin - K se usa para temperatura

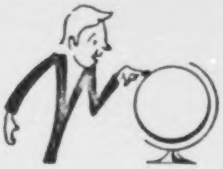
Para el uso diario solamente las tres primeras unidades básicas, para volumen líquido (litro), se usan comunmente.

Examinemos la unidad métrica de longitud.

1. El metro es la unidad básica de longitud. Es una medida de extensión o distancia. Actualmente se define desde el punto de vista de una "longitud de onda" de manera que pueda ser chequeado para exactitud en cualquier laboratorio bien equipado.

Unidad básica de longitud: metro ("metre" o meter en Inglés).

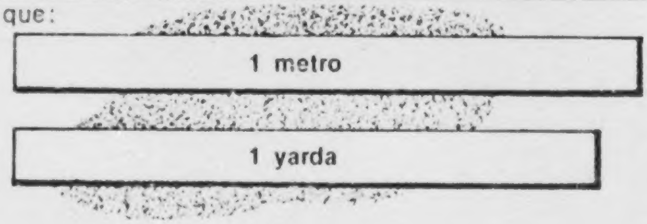
símbolo - m (Note que el símbolo para el prefijo mili es también m.) Estos son símbolos no abreviaciones y por eso no se usan puntos.

	Unidades Métricas Comunes		Uso	Expresadas en Metros
	nombre	símbolo		
	milímetros	mm	Medida muy pequeña para todo trabajo técnico e industrial	1/1000 de metro = 0.001 m 1000 mm = 1m
	centímetros	cm	Para medida del cuerpo y de la ropa y usos caseros.	1/100 de metro = 0.01 m 100 cm = 1 m
	metro	m	Para medidas más grandes tales como tamaños de edificios.	1 m
	kilómetro	km	Para distancias entre ciudades y otras distancias muy grandes.	1000 veces un metro o 1000 m

Todo lo que usted necesita saber acerca del metro es que:

Es un poquito más largo que una yarda (acerca de 3.37")

Se divide en unidades más pequeñas y más grandes de diez en diez como nuestro dinero.



Hay 10 decímetros en un metro, 100 centímetros en un metro y 1000 milímetros en un metro.

Los prefijos para mostrar unidades de 10 se usan para todas las unidades métricas, no solamente para longitud. Las más comunes son kilo - k = 1000, centi - c = 1/100 y mili - m = 1/1000.

Note también cómo es de fácil para usted cambiar las unidades corriendo el punto decimal.

1.0 metro

0.1 metro = 1 decímetro

0.01 de metro = 1 centímetro

0.001 de metro = 1 milímetro

El punto decimal se corre a la **izquierda** para cambiar de las unidades más pequeñas a las más grandes. Por ejemplo, 2235 mm es también 2.235 m. El punto decimal se corre a la derecha de las unidades más grandes a las más pequeñas. Para cambiar km a m, corra el punto decimal tres lugares a la derecha.

Ejemplo: 3.565 km son también 3565 m. Para cambiar m a mm, corra el punto decimal tres lugares a la derecha. **Ejemplo:** 1.125 m son también 1125 mm.

Recuerde que:

- **el metro es un poquito más largo que la yarda.**
- **hay 1000 milímetros en un metro**
- **300 milímetros son casi iguales a 1 pie**

El dinero en lo métrico -- Ya estamos usando diariamente una especie de sistema métrico -- el dinero.

Note como la medida métrica, un sistema decimal, es exactamente como nuestro dinero.

SU DINERO Y LA LONGITUD METRICA

SU DINERO	LONGITUD METRICA	SIMBOLO	NUMERO DE METROS
$1,000.00	kilómetro	km	1000.
$100.00	hectómetro	hm	100.
$10.00	decámetro	dam	10.
$1.00	metro	m	1.
DIEZ CENTAVOS ○	decímetro	dm	0.1
CENTAVO ○	centímetro	cm	0.01
MIL 	milímetro	mm	0.001

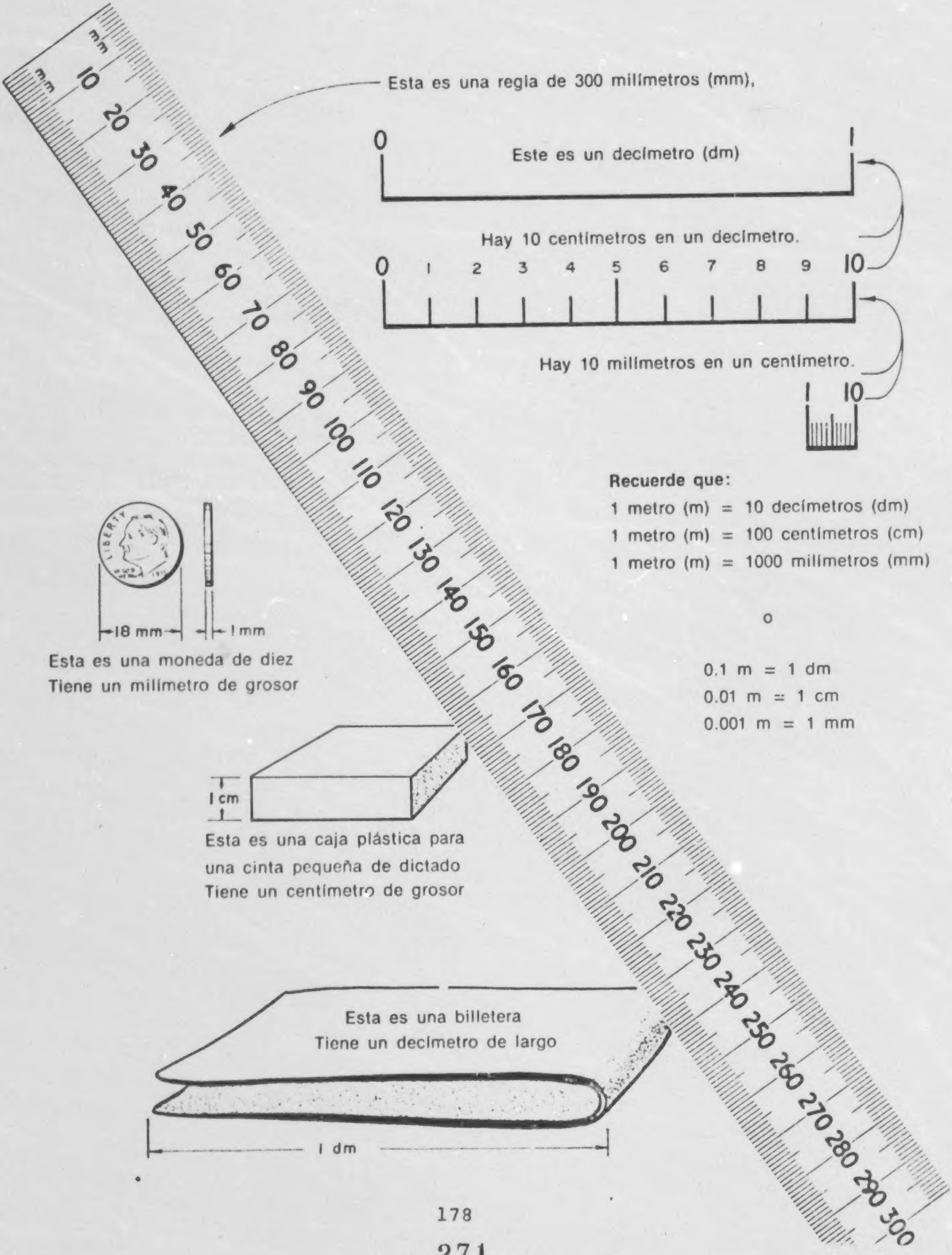
Para distancias más grandes, se usa el kilómetro (1000 metros). Es cerca de 5/10 de milla, u 8 kilómetros son casi iguales a 5 millas. Por ejemplo, la distancia de Chicago a Denver es cerca de 1 600 kilómetros (1 000 millas).

CONVERSIONES APROXIMADAS

Longitud

Simbolo	Cuando Usted Sabe	Multiplica por	Para Hallar	Simbolo
mm	milímetros	0.04	pulgadas	pg
cm	centímetros	0.4	pulgadas	pg
m	metros	3.3	pies	p
m	metros	1.1	yardas	yd
km	kilómetros	0.6	millas	mi
pg	pulgadas	25.4*	milímetros	mm
pg	pulgadas	2.54*	centímetros	cm
p	pies	30	centímetros	cm
yd	yardas	0.9	metros	m
mi	millas	1.6	kilómetros	km

*Exacto


mm
mm
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
200
210
220
230
240
250
260
270
280
290
300
0
1
0
1
2
3
4
5
6
7
8
9
10
1
10
18 mm
1 mm
1 cm
1 dm

Esta es una regla de 300 milímetros (mm),

Este es un decímetro (dm)

Hay 10 centímetros en un decímetro.

Hay 10 milímetros en un centímetro.

Recuerde que:

1 metro (m) = 10 decímetros (dm)
1 metro (m) = 100 centímetros (cm)
1 metro (m) = 1000 milímetros (mm)

o

0.1 m = 1 dm
0.01 m = 1 cm
0.001 m = 1 mm

Esta es una moneda de diez
Tiene un milímetro de grosor

Esta es una caja plástica para
una cinta pequeña de dictado
Tiene un centímetro de grosor

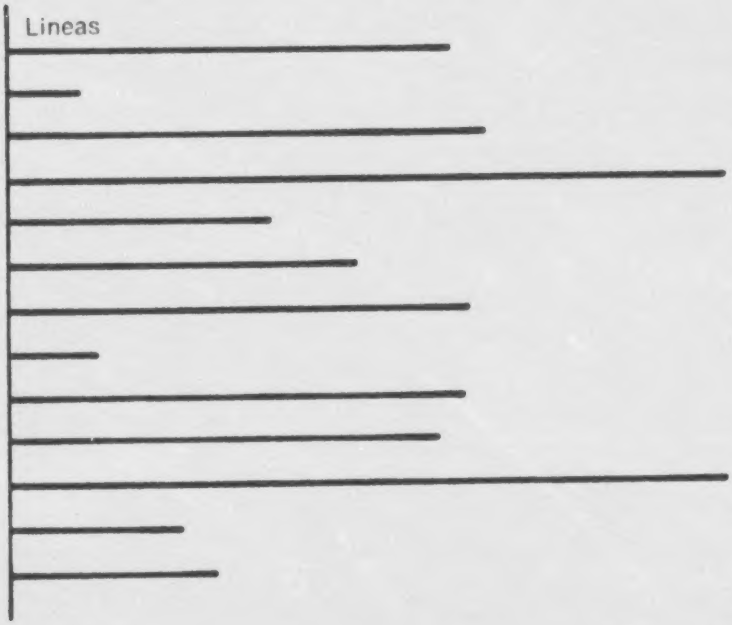
Esta es una billetera
Tiene un decímetro de largo

MIDA EL LARGO DE ESTAS LINEAS

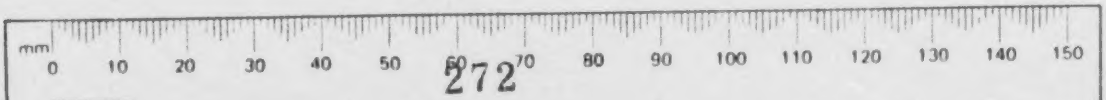
Abajo hay una lista de dimensiones de artículos usuales. Use su regla métrica para chequear el largo de cada línea para determinar el artículo que representa. Coloque la letra de artículo y el largo de la linea en los espacios.

A. ancho de una transparencia (50 mm)
B. ancho de un sobre comercial (105 mm)
C. largo de una estampilla de correo (25 mm)
D. diámetro de un botón (10 mm)
E. diametro de una moneda de 50 centavos (30 mm)
F. ancho de un billete de dolar (65 mm)
G. ancho de la cuchilla de una sierra (13 mm)
H. diámetro de un tarro de pintura (107 mm)
I. diámetro de una taza (67 mm)
J. ancho de una placa de interruptor eléctrico (70 mm)
K. grosor de una tabla de 2 x 4 (38 mm)
L. ancho de una tabla de 2 x 4 (89 mm)
M. ancho de una cinta de grabar cassette (63 mm)

(Mida desde la línea vertical)



Letra del Artículo	Longitud de la línea
	mm
	mm
	mm
	mm
	mm
	mm
	mm
	mm
	mm
	mm
	mm
	mm
	mm



SI metric . . . el sistema internacional de unidades

EXAMINESE USTED MISMO

1. La unidad base de longitud del SI es el_______.

2. El símbolo para la unidad base de longitud del SI es_______.

3. Nuestro sistema de moneda es un sistema decimal. El dolar se divide en 10 monedas de diez centavos, 100 centavos en 1000 milésimas. La medida métrica es también un sistema_______.

4. El prefijo para una centésima de metro es el_______.

5. Hay_______centímetros en un metro.

6. La unidad métrica de longitud usada para la medida del cuerpo y de la ropa es el_______.

7. El prefijo para una milésima de metro es_______.

8. Hay_______milímetros en un metro.

9. La unidad métrica de longitud usada para todo trabajo industrial y técnico es el_______.

10. El prefijo para mil veces el metro es_______.

11. El símbolo para mil veces el metro es_______.

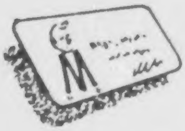
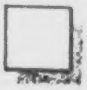
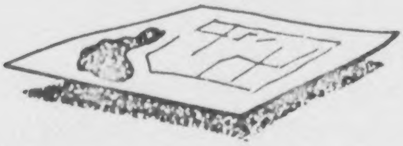
12. La unidad métrica para distancias largas que reemplaza las millas es el_______.

Respuestas

1. metro (metre)
2. m
3. decimal
4. centi
5. 100
6. centímetro
7. mili
8. 1000
9. milímetro
10. kilo
11. k
12. kilómetro

Unidad de superficie: metro cuadrado (metre cuadrado)

símbolo - m^2

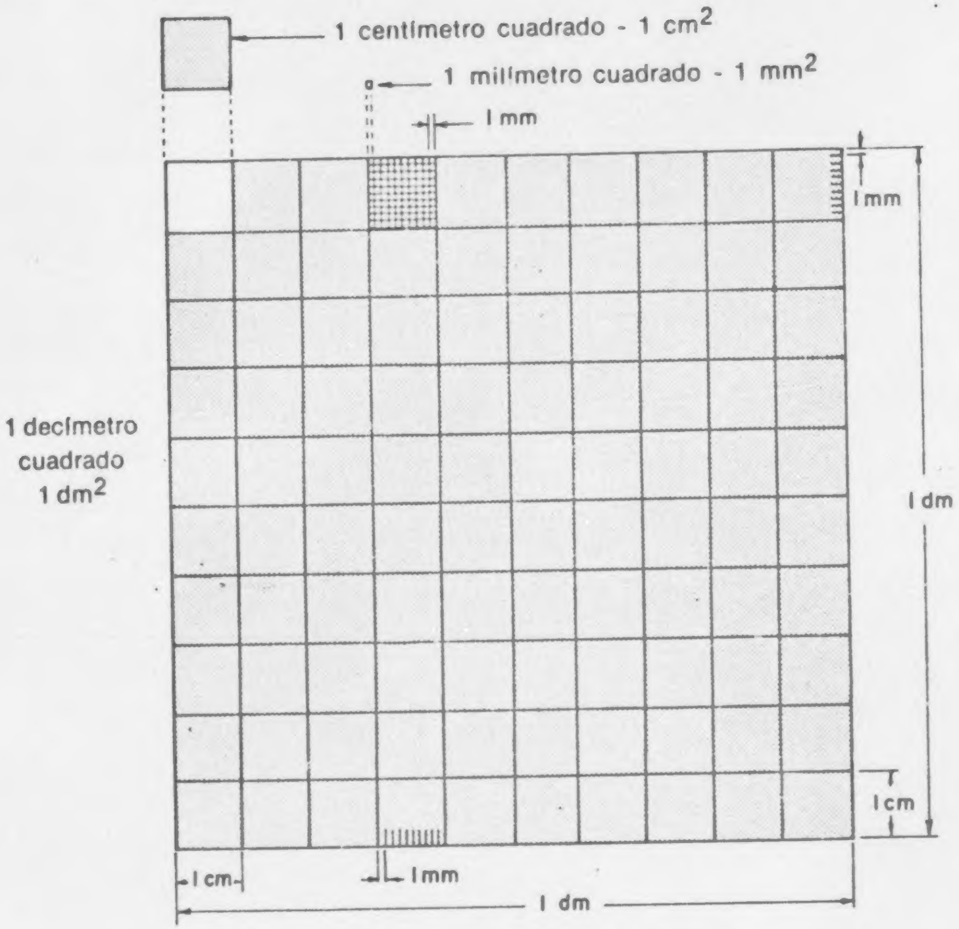
	Unidades Métrica Comunes		Uso	Expresadas en Metros Cuadrados
	Nombre	Símbolo		
	milímetro cuadrado	mm^2	Superficies muy pequeñas	1/1 000 000 de metro cuadrado - 0.000 001 m^2
	centímetro cuadrado	cm^2	Superficies pequeñas para uso de la vida diaria tal como tarjetas personales	1/10 000 de metro cuadrado 0.000 1 m^2
	decímetro cuadrado	dm^2	Usado solamente en la enseñanza.	1/100 de metro cuadrado - 0.01 m^2
	metro cuadrado	m^2	Superficies grandes tales como alfombras.	1 metro cuadrado o 1 m2
	hectarea	ha	Usada para medir terreno - granjas, estancias, etc.	diez mil metros cuadrados o 10 000 m^2
	kilómetro cuadrado	km^2	Usado para superficies de terreno muy grandes	un millón de metros cuadrados o 1 000 000 m^2

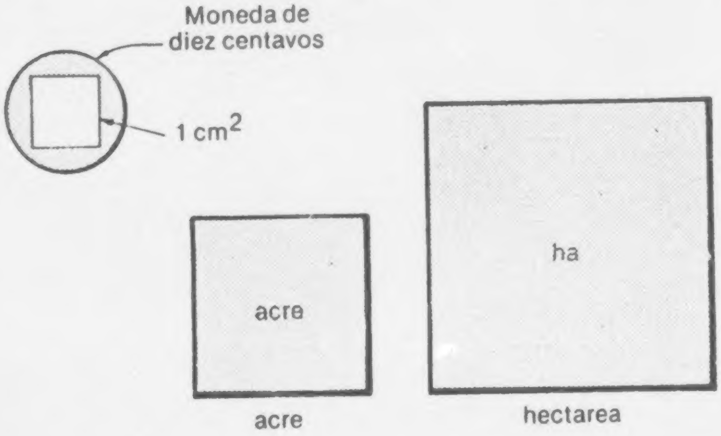
Para hayar superficie, usted debe multiplicar dos dimensiones - largo por ancho o lado por lado. Por ejemplo, si una mesa grande mide 2 metros por 1.5 metros, la superficie es igual 2.3 metros cuadrados (3 m^2). Un metro cuadrado (cada lado tiene 39.37" de largo) es casi 20% más grande en superficie que una yarda cuadrada. Un metro cuadrado es casi el tamaño de un cuarto de baño corriente. Un centímetro cuadrado (cm^2) fácilmente cabrá en la superficie de una moneda de diez. Hay una diferencia tan grande entre un metro cuadrado y un kilómetro cuadrado que se necesita una unidad métrica dentro de estas dos medidas. Esta unidad, llamada la hectarea (ha) se usa para medir terreno. Es igual a casi 2-1/2 acres (2.47) o al tamaño de unas diez piscinas olímpicas.

Superficie

Simbolo	Cuando Usted Sabe	Multiplica por	Para Hallar	Simbolo
cm^2	centimetros cuadrados	0.16	pulgadas cuadradas	pg^2
m^2	metros cuadrados	1.2	yardas cuadradas	yd^2
km^2	kilómetros cuadrados	0.4	millas cuadradas	mi^2
ha	hectareas (10 000 m^2)	2.5	acres	
pg^2	pulgadas cuadradas	6.5	centimetros cuadrados	cm^2
p^2	pies cuadrados	0.09	metros cuadrados	m^2
yd^2	yardas cuadradas	0.8	metros cuadrados	m^2
mi^2	millas cuadradas	2.6	kilómetros cuadrados	km^2
	acres	0.4	hectareas	ha

AREA


1 centímetro cuadrado - 1 cm²
1 milímetro cuadrado - 1 mm²
1 mm
1 mm
1 decímetro cuadrado 1 dm²
1 dm
1 cm
1 cm
1 mm
1 dm


Moneda de diez centavos
1 cm²
acre
acre
ha
hectarea

No hay escala

EXAMINESE USTED MISMO

1. La unidad SI de superficie es el_______ _______.

2. El símbolo de la unidad SI de superficie es_______ .

3. Un decímetro cuadrado es _______ (en la forma decimal) de un metro.

4. Hay _______ millón de milímetros cuadrados en un metro cuadrado.

5. Un rectángulo que mide 6 centímetros por 9 centímetros tiene una superficie de _______ centímetros cuadrados.

6. Un metro cuadrado es casi el _______ por ciento más grande que la yarda cuadrada.

7. Un cuarto que mide 3000 milímetros por 5000 milímetros necesitaría _______ metros cuadrados de alfombra.

8. Una hectarea es igual a _______ mil metros cuadrados.

9. Una hectarea es alrededor de _______ veces más grande que un acre.

10. Una parcela de tierra de 25 acres tendría alrededor de _______ hectareas.

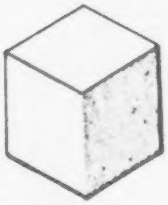
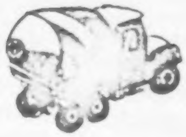
Respuestas

1. metro cuadrado
2. m^2
3. $0.01\ m^2$
4. 1
5. 54
6. 20
7. 15
8. 10
9. 2-1/2
10. 10

Usted no solamente debe medir longitud y superficie sino **volumen** también. Volumen es una medida de espacio ocupado.

Unidad de volumen: el metro cúbico

símbolo - m^3

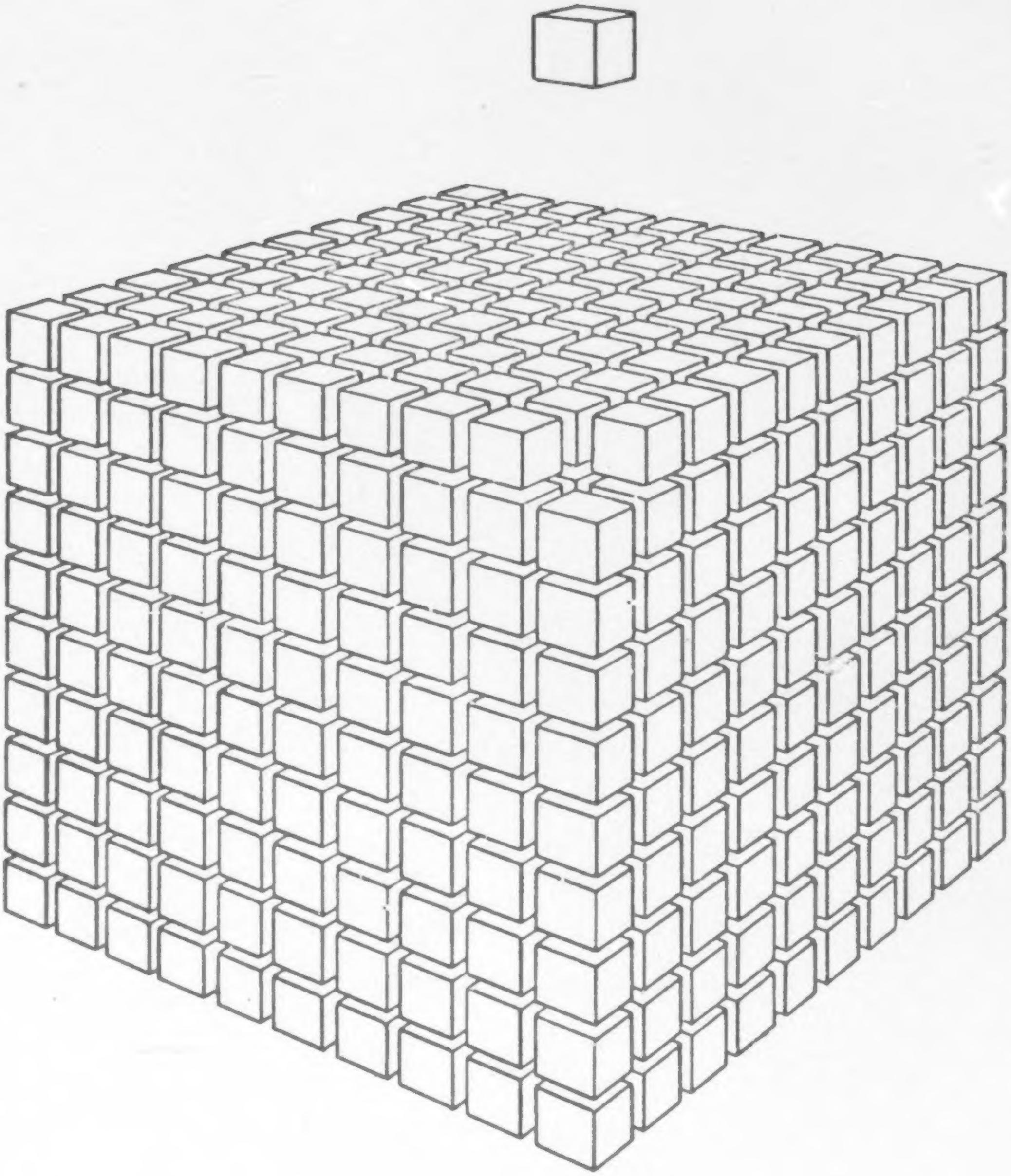
	Unidades Métricas Comunes		Uso	Expresados en Metros Cúbicos
	Nombre	Símbolo		
	centímetro cúbico	cm^3	volúmenes muy pequeños para dosis en medicina	1/1 000 000 de metro cúbico o 0.000 001 m^3
	decímetro cúbico	dm^3	volumenes pequeños similares a un cuarto. Un decímetro cúbico es igual a un litro.	1/1000 de metro cúbico o 0.001 m^3
	metro cúbico	m^3	volumenes grandes tales como los usados para cemento, gravilla etc.	1 m^3

Un cubo con lados que miden 1 metro es un metro cúbico (m^3). Es alrededor del 30 por ciento más grande que una yarda cúbica. Si un metro cúbico fuera un recipiente abierto, sería lo suficientemente grande para que varios chicos de 12 años se pararan dentro con sus codos tocando los lados del recipiente. Note que el volumen se obtiene multiplicando longitud por longitud x longitud x longitud. Un decímetro cúbico (dm^3) es un cubo que mide 1 decímetro (1/10 de metro) por cada lado. Como usted tiene que multiplicar largo x ancho x alto para superficie cúbica, un decímetro cúbico igualaría a 1/10 m x 1/10 m x 1/10 m o 1/1000 0.1 m x 0.1 m x 0.1 m = 0.001 m^3 (una milésima) de metro cúbico. Al decímetro cúbico (dm^3) se le da el nombre especial de "litre" o litro (l o ℓ) cuando se usa para medidas líquidas. El centímetro cúbico (cm^3), un volumen muy pequeño, es igual a un mililitro.

CONVERSION APROXIMADA

Volumen

Símbolo	Cuando Usted Conoce	Multiplica Por	Para Hallar	Símbolo
m^3	metro cúbico	35	pie cúbico	p^3
m^3	metro cúbico	1.3	yarda cúbica	yd^3
p^3	pie cúbico	0.03	metros cúbicos	m^3
yd^3	yarda cúbica	0.76	metros cúbicos	m^3



La figura grande de arriba representa 1 decímetro cúbico o litro. Cada lado de 1 decímetro cúbico tiene 10 cm de largo. La figura pequeña de más arriba representa 1 centímetro cúbico (1 cm^3). Hay **1000** cm^3 en 1 dm^3. Cada lado de 1 cm^3 tiene 10 mm de largo. Un decímetro cúbico contendrá 1 "litre" (1 litro) de volumen liquido. Un centímetro cúbico contendrá 1 mililitro.

EXAMINESE USTED MISMO

1. La unidad SI de volumen es el________.

2. El símbolo para la unidad de volumen es________.

3. Un metro cúbico es alrededor de________por ciento más grande que una yarda cúbica.

4. Cuando se usa un decímetro cúbico para medidas líquidas se le llama________.

5. Un recipiente que mide 4 x 6 x 8 cm tendría un volumen de________cm^3.

6. Un recipiente grande que mide 5 x 12 x 14 m tendría un volumen de________m^3.

7. Un centímetro cúbico es igual a una________de metro cúbico.

8. Complete lo siguiente en metros cúbicos (m^3).

Ancho	Alto	Largo	m^3
2 m	3 m	6 m	
3 m	5 m	8 m	
11 m	14 m	24 m	

9. Un metro cúbico es igual alrededor de________yardas cúbicas.

10. Una yarda cúbica es igual alrededor de________metros cúbicos.

Respuestas

1. metro cúbico
2. m^3
3. 30
4. litro
5. 192
6. 840
7. millonésima
8. a. 36
   b. 120
   c. 3696
9. 1.3
10. 0.76

Para cantidades más grandes que un litro, use el kilolitro (kl) que es igual a 1 000 litros y es también 1 metro cúbico (m^3).

Recuerde:

- 1 metro cúbico es igual a 1 kilolitro
- 1 decímetro cúbico es igual a 1 litro
- 1 centímetro cúbico es igual a 1 mililitro.

Un **litro** tiene un volumen de 1000 centímetros cúbicos (un decímetro cúbico) y si se llena con agua pesará 1000 gramos (1 kilogramo).

CONVERSION APROXIMADA

Volumen Líquido

Símbolo	Cuando Usted Conoce	Multiplica Por	Para Hallar	Símbolo
ml	mililitros	0.03	onzas líquidas	oz lq
ℓ o l	litros	2.1	pintas	pt
ℓ o l	litros	1.06	cuartos	qt
ℓ o l	litros	0.26	galones U.S.	gal
ℓ o l	litros	0.22	galones Imp	gal
cdt	cucharaditas	5	mililitros	ml
cd	cucharadas	15	mililitros	ml
oz lq	onzas líquidas	30	mililitros	ml
c	tazas	0.24	litros	ℓ or l
pt	pintas	0.47	litros	ℓ or l
qt	cuartos	0.95	litros	ℓ or l
gal	galones EEUU	3.8	litros	ℓ or l
gal	galones Imp	4.5	litros	ℓ or l

EXAMINESE USTED MISMO

1. Un decímetro cúbico es igual a la unidad de volumen líquido conocido como el _______.

2. Hay _______ litros en un metro cúbico.

3. Un tanque grande de gasolina que tiene 2 metros de alto, 2 metros de ancho y 2 metros de profundidad contendrá _______ litros.

4. Si usted virtiera un litro de pintura dentro de un tarro de un cuarto, esta se derramaría. Sí ____ No ____

5. Sí usted virtiera dos tarros de aceite, de una pinta cada uno, dentro de un recipiente de un litro, el aceite se derramaría. Sí ____ No ____

6. Una caja que tiene por dentro las dimensiones de 20 cm de alto por 70 cm de largo por 40 cm de ancho tiene una capacidad de _______ litros.

7. Un galón de los E.E.U.U. es igual alrededor de _______ litros.

8. Seis cuartos igualan alrededor de _______ litros.

9. Diez litros igualan alrededor de _______ galones de los E.E.U.U.

10. Un tanque de gas de 20 galones contendrá _______ litros de gas.

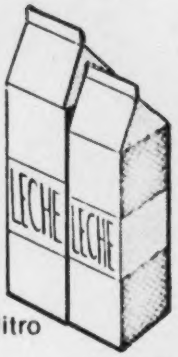
Respuestas

1. litro
2. 1000
3. 8000
4. Sí
5. no
6. 56
7. 3.8
8. 5.7
9. 2.6
10. 76

Ahora usted aprenderá a medir líquidos.

Unidad de volumen líquido o capacidad: El litre o litro

símbolo - ℓ o l

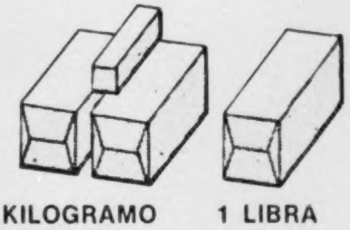


1 CUARTO

	Unidades Métricas Comunes		Uso	Expresados en Litros
	Nombre	Símbolo		
	mililitro	ml	Usado para dosis en la medicina, también para Todas las medidas líquidas menores que el tamaño de un litro. Por ejemplo, 500 ml igualan a la mitad de un litro.	0.001 litro 1/1000 o 0.001 litro
	litro	ℓ o l	Usado para todo volumen líquido, antes, un cuarto en tamaño. La gasolina, el aceite, la leche se comprarán en el tamaño de un litro.	1 litro
	kilolitro	kl	Usado para recipientes muy grandes tales como carro tanques de gasolina o leche. También los medidores de agua de las casas se graduarán en kilolitros o metros cúbicos.	1000 litros

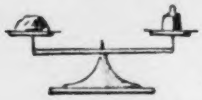
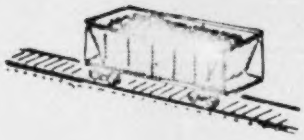
Como usted ya sabe, la unidad de medida de volumen líquido es el litre (litro). El litro, igual a 1 decímetro cúbico, es un poquito más que un cuarto (1.06). 1000 milímetros igualan a 1 litro. 500 ml igualan a 0.5 de litro. 250 ml igualan a 0.25 de litro. Un mililitro es igual a un centímetro cúbico.

Ahora usted aprenderá a medir pesos. Peso es una medida relacionada con la carga. Para el uso diario la masa y el peso son la misma cosa. El patron para el kilogramo es la aleación de platino - iridio.



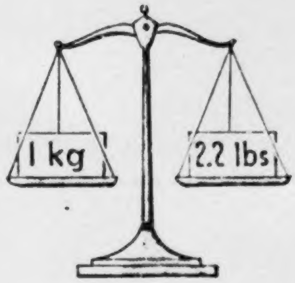
Unidad de Peso (masa): El kilogramo

símbolo - kg

	Unidades Métricas Comunes		Uso	Expresadosen g or kg
	NOMBRE	SIMBOLO		
	miligramo	mg	Usado para cantidades demasiado pequeñas, tales como en farmacia y en vitaminas.	1 mg = 0.001 g 1000 mg = 1 g
	gramo	g	Usado en la medida de pequeñas cantidades tales como cereales del desayuno, mantequilla, hilado	1 g = 0.00k kg 1000 g = 1 kg
	kilogramo	kg	Usado en la medida de cantidades más grandes, tales como papas, manzanas, talegos de azucar, carnes	1000 g = 1 kg
	tonelada métrica (tonne)*	t	Usada en la medida de cantidades muy grandes tales como carbón, mineral de hierro, arena,gravilla, etc.	1 000 000 g = 1 000 kg = 1 t

*Término usado en Canadá

El peso y la masa no siempre se consideran la misma cosa. Para usos prácticos de la vida diaria, sin embargo, usted puede pensar en masa y peso como si fueran lo mismo. Un kilogramo tiene alrededor de 2.2 libras. 500 gramos son alrededor del 10 por ciento más grandes que una libra. Una presilla de papel pesa alrededor de 1 gramo mientras que una moneda de cinco pesa 5 gramos.



Hay 1 000 gramos en un kilogramo y mil kilogramos igualan a una tonelada métrica.

CONVERSIONES APROXIMADAS

Peso (Masa)

Simbolo	Cuando Usted Conoce	Multiplica Por	Para Hallar	Simbolos
g	gramos	0.035	onzas	oz
kg	kilogramos	2.2	libras	lb
t	toneladas métricas (1000 kg)	1.1	toneladas mermadas	
oz	onzas	28	gramos	g
lb	libras	0.45	kilogramos	kg
	toneladas mermadas (2000 lb)	0.9	toneladas métricas	t

1000 mg = 1 g

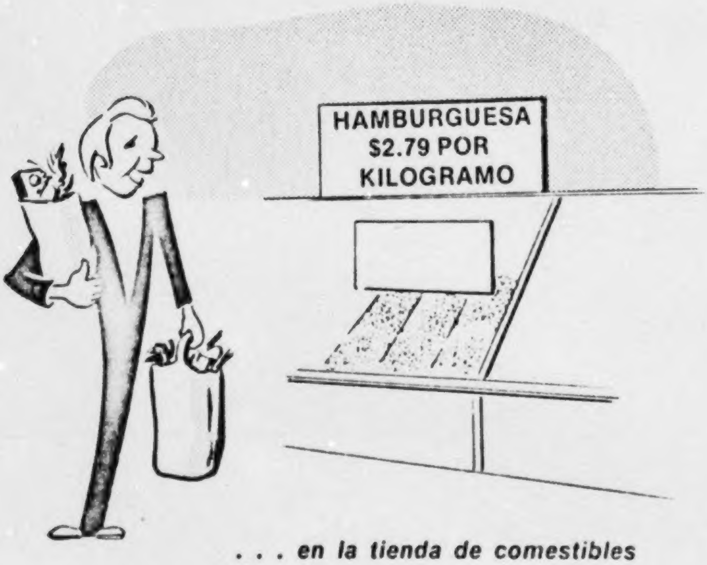
1000 g = 1 kg

1000 kg = 1 t

mg (miligramo)

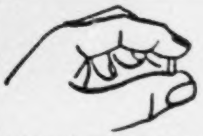
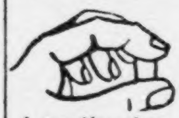
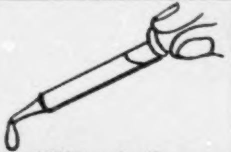
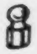
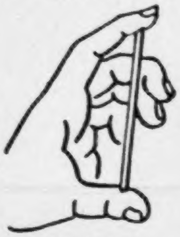
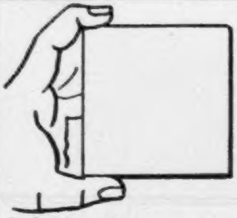
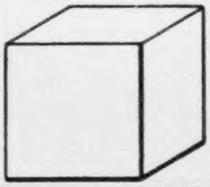
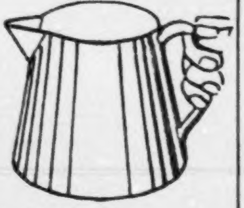
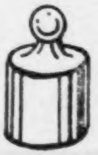
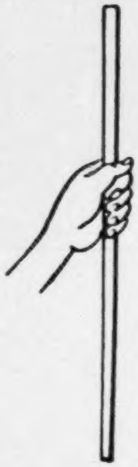
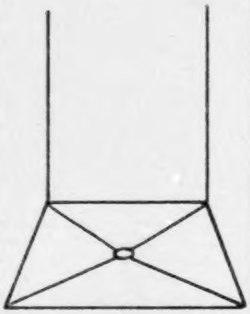
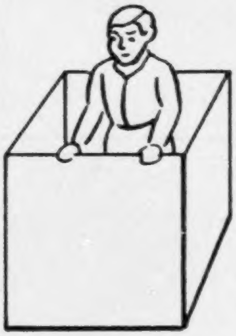
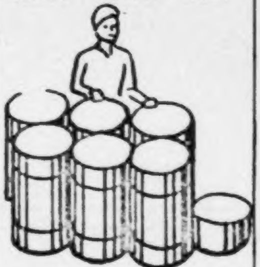
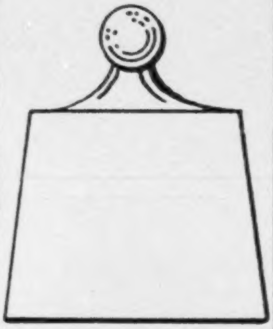
g (gramo)

kg (kilogramo)



. . . en la tienda de comestibles

En el sistema métrico hay una relación directa entre longitud, superficie volumen, capacidad líquida y peso.

LONGITUD	SUPERFICIE	VOLUMEN	CAPACIDAD LIQUIDA	PESO (MASA) DEL AGUA
 1 centímetro (cm)	 1 centímetro cuadrado (cm^2)	1 centímetro cúbico (cm^3)	 1 mililitro (ml)	 1 gramo (g)
 1 decímetro (dm)	 1 decímetro cuadrado (dm^2)	 1 decímetro cúbico (dm^3)	 1 litro (*l*)	 1 kilogramo (kg)
 1 metro (m)	 Cuarto de baño 1 metro cuadrado (m^2)	 1 metro cúbico (m^3)	 Cada barril contiene 42 galones o alrededor de 160 litros. 6.25 barriles de aceite. 1 kilolitro (kl)	 1 tonelada métrica o tonne* (t)

*Término usado en Canadá y en otros países de habla inglesa.

EXAMINESE USTED MISMO

1. Trescientos gramos añadidos a 1 kilogramo igualarían a ______ gramos.
2. Cuatro mil doscientos kilogramos igualan a ______ toneladas métricas.
3. Cambie 120 mg a ______ g.
4. Cambie 2525 g a ______ kg.
5. Productor A cobra 42.00 por tonelada métrica de cemento mientras productor B cobra 5¢ por kilogramo. ¿Cuál es más barato, A o B?
6. Se tienen los siguientes ingredientes para mezclay y hacer un batido para ponque. ¿Cuál es el peso total en kilogramos? ______ kg

6. 200 gramos de mantequilla
   275 gramos de azúcar
   50 gramos de chocolate
   250 gramos de harina
7. Cuatro libras igualan alrededor de ______ kg.
8. Tres kilogramos igualan alrededor de ______ lb.
9. Dos libras más 6 libras igualan alrededor de ______ kg.
10. Dos toneladas métricas igualan a ______ toneladas métricas.

Respuestas

1. 1300
2. 4.2
3. 0.120
4. 2.525
5. A
6. 0.775
7. 1.8
8. 6.6
9. 3.6
10. 2.2

Temperatura

La unidad SI de medida de temperatura es el Kelvin (K), el cual se usa solamente en aplicaciones científicas. Para propósitos de la vida diaria, se usa la escala Celsio (reemplazando la escala antigua centígrada). Temperatura es la medida del frío o del calor.

Unidad: grados Celsio

símbolo: °C

Las siguientes son las relaciones entre las escalas Celsio y Fahrenheit:

- El agua hierve a 100 °C y a 212 °F
- Una habitación 21 °C y 70 °F.
- El agua se congela a 0 °C y a 32 °F.
- La temperatura normal del cuerpo humano es de 37 °C y 98.6 °F.

Piense en temperaturas métricas:

35 a 40 °C	Condiciones de la ola calorífica
30 °C	Ardiente
25 °C	Caliente
20 °C	Templado
15 °C	Fresco
5 a 10 °C	Frío

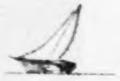
Si usted convierte de grados Celsio a grados Fahrenheit, use una tabla de conversiones o haga lo siguiente: doble la temperatura Celsio, reduzca el 10% y entonces añada 32. Por ejemplo, si la temperatura es de 20 °C, entonces dos veces 20 son 40; menos el 10%°36, entonce añada 32 a 36 para obtener la temperatura de 68 °F. Con un poquito de práctica usted puede hacer esto en su cabeza.

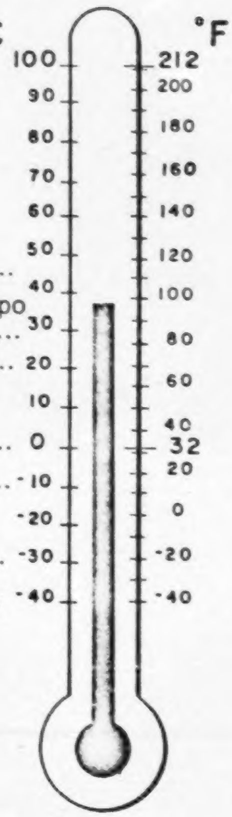
Temperatura

está en °C (grados Celsio)

ESTACIONES

	°C	°F
PRIMAVERA	20	68
VERANO	30	86
OTOÑO	10	50
INVIERNO	-20	- 4




°C
100
90
80
70
60
50
40
30
20
10
0
-10
-20
-30
-40
°F
212
200
180
160
140
120
100
80
60
40
32
20
0
-20
-40

ola calorífica.................

37°C temperatura normal del cuerpo humano natación.......................

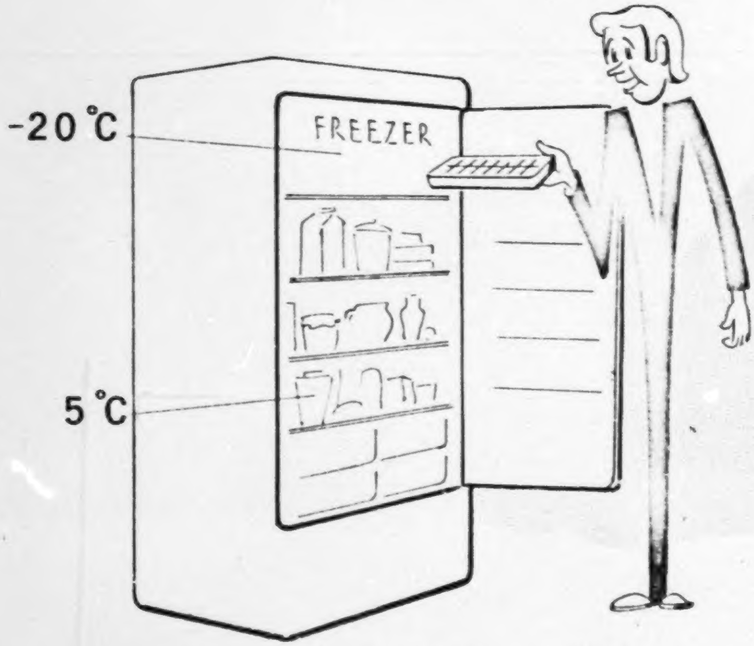
temperatura de una habitación.......

punto de congelación del agua......

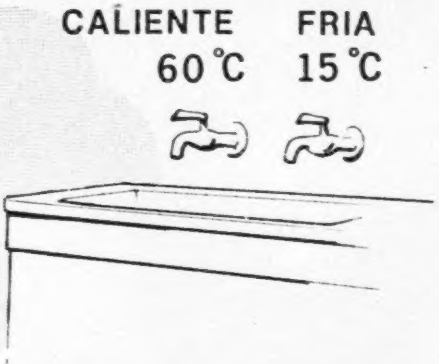
patinando en la laguna.................

problemas con la batería..............

sentándose cerca a la chimena.....


-20 °C
FREEZER
5 °C

Refrigerador

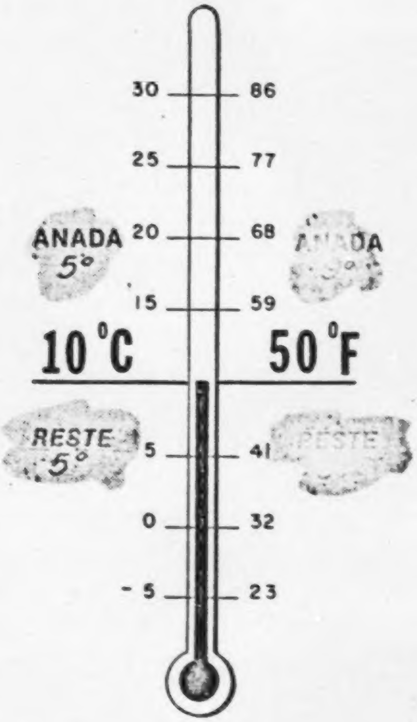

CALIENTE
60 °C
FRIA
15 °C

Temperatura

Otra forma de recordar las temperaturas del tiempo es la siguiente:

10 grados Celsio igualan a 50 grados Fahrenheit.

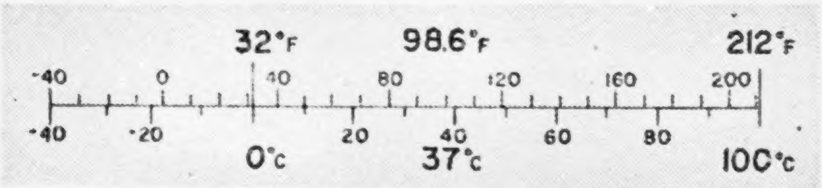
Por cada 5 grados añadidos a la temperatura Celsio añada 9 grados a la temperatura Fahrenheit. Por ejemplo, 15 grados Celsio igualan a 59 grados Fahrenheit o 20 grados Celsio igualan a 68 grados Fahrenheit.


30
86
25
77
ANADA 5°
20
68
ANADA
15
59
10°C
50°F
RESTE 5°
5
41
RESTE
0
32
- 5
23

CONVERSION (EXACTA)

Temperatura

Simbolo	Cuando Usted Sabe	Multiplique Por	Para Hallar	Simbolo
°C	grados Celsio	9/5 (entonces añada 32)	temperatura Fahrenheit	°F
°F	temperatura Fahrenheit	5/9 (después de restar 32)	grados Celsio	°C


32°F
98.6°F
212°F
-40
0
40
80
120
160
200
-40
-20
20
40
60
80
0°C
37°C
100°C

EXAMINESE USTED MISMO

1. Cambie estas temperaturas del tiempo de grados Fahrenheit a grados Celsio.

   A. 68 °F igualan a ______ °C.

   B. 50 °F igualan a ______ °C.

   C. 59 °F igualan a ______ °C.

2. Una temperatura alta de 104 °F en el desierto sería _______ en grados Celsio.

3. Si la temperatura de una persona sube a 37.5 °C, Cuál sería la temperatura en grados Fahrenheit? _______ .

4. Complete estos problemas de conversiones.

   A. 90 °C = ______ °F.

   B. 25 °F = _______ °C.

   C. 180 °C = _______ °F.

5. El compartimento principal de un refrigerador tiene acerca de _______ °C.

6. El agua caliente de la llave del agua tiene acerca de _______ °C.

7. Un día caliente de verano subiría a ______ °C.

8. El congelador de un refrigerador tiene acerca de _______ °C.

9. El agua fría de la llave de agua tiene acerca de _______ °C.

10. Un día frío de invierno baja acerca de _______ °C.

Respuestas

1. a. 20
. b. 10
. c. 15
2. 40
3. 99.5
4. a. 194
. b. -3.9
. c. 356
5. 5
6. 60
7. 30
8. -20
9. 15
10. -20

UNIDADES TECNICAS

Hay muchas unidades técnicas usadas en la industria y en la tecnología. Sinembargo, solamente unas pocas de estas se usan en la vida diaria.

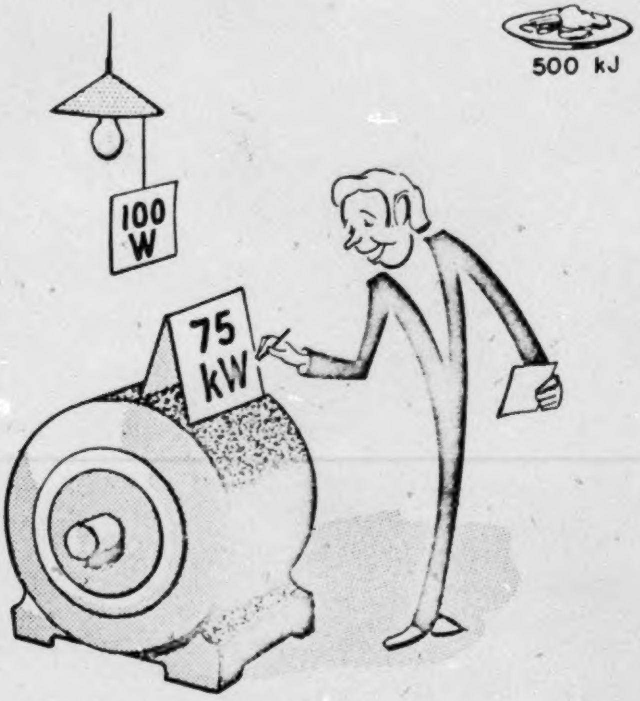
1. **Velocidad.** La velocidad en el SI métrico se da en metros por segundo. Sinembargo los límites de velocidad de las autopistas se señalarán en kilómetros por hora (km/h). Como el kilómetro tiene solo 5/8 de milla, los números para la misma velocidad serán mayores en millas por hora.

2. **Fuerza.** En el sistema métrico la fuerza se da en **newtons** (N). La fuerza de gravedad sobre un kilogramo masa sería de 9.8 newtons al nivel del mar y 1.6 newtons en la luna. La fuerza de gravedad sobre un hombre con 80 kilogramos (176 libras) sería de 784 newtons sobre la tierra y de 128 newtons en la luna. Por esta razón el astronauta puede saltar más alto en la luna que en la tierra.

3. **Presión.** La unidad de presión es el pascal (Pa). Esta es una unidad pequeña. Por ejemplo una manzana de tamaño mediano (100 gramos) apretada suavemente sobre una mesa de 1 metro cuadrado, ejercería una presión de más o menos un pascal. Por eso, las presiones se dan en kilopascales (1000 pascales). 1 psi (libra por pulgada cuadrada) es igual a cerca de 7 kilopascales. Si la presión de sus llantas es de 25 libras por pulgada cuadrada (psi), en el sistema métrico es de 170 kilopascales. Una llanta de bicicleta ejerce una presión de 200 a 350 kPa y alrededor de 100 kPa son el patrón de presión atmosférica.

4. Energía. La unidad de energía o trabajo es el julio (J). Esta es una unidad muy pequeña así que hay que usar el kilojulio (kJ). Cerca de 4.2 kilojulios igualan a una Caloría de alimento (kilocaloría). Una dieta de 2000 Calorías sería una dieta de 8400 kilojulios.

5. Poder. La unidad de todo poder (no solamente de electricidad) se da en vatios (W) o kilovatios (kW). Un tamaño común de una lámpara elétrica consume 100 vatios. Un caballo de fuerza iguala aproximadamente 2-3/4 kilovatios (kW). Por eso, un motor de 100 caballos de fuerza sería un motor de 75 kilovatios.

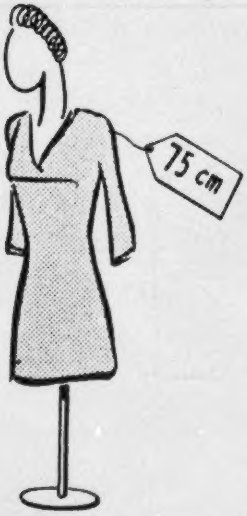


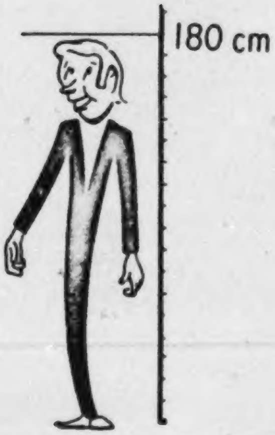
LO METRICO EN LO DOMESTICO

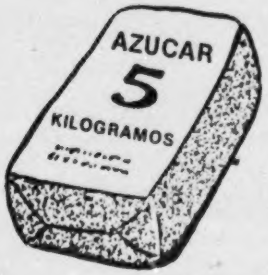
1. Todas las tallas, de cuerpo, ropa y la mayoría de los artículos comprados para el hogar se medirán en centímetros excepto los artículos como alfombras, los cuales se medirán en metros cuadrados. Las tallas de ropa mostrarán medidas comunes en centímetros, aproximadamente 2.5 centímetros en cada pulgada. Una cintura de 30 pulgadas sería una cintura de 75 centímetros. Un cuarto típico de 10 pies por 12 pies mediría 3 por 3.7 metros (3 000 x 37 000 mm). Requeriría aproximadamente 11 metros cuadrados de alfombra en vez de 13 yardas cuadradas.

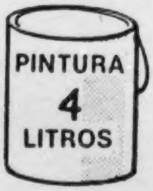
2. Los comestibles y otros objetos caseros se comprarían por peso en gramos y kilogramos. El kilogramo tiene aproximadamente 2.2 libras.

3. Los líquidos se comprarían por litros; el litro es aproximadamente el 6 por ciento más grande que el cuarto.







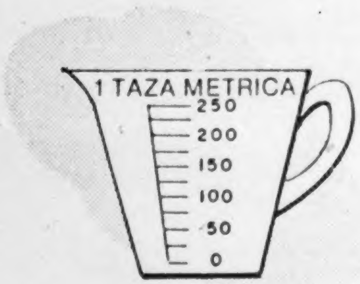


LONGITUD Y SUPERFICIE

Unidades antiguas	Unidades Métricas
1 pulgada o 2.54 cm	2.5 centímetros
1 pulgada o 25.4 mm	25 milímetros
6 pulgadas o 152.4 mm	150 milímetros
12 pulgadas o 305 mm	300 milímetros
1 yarda o 914 mm	1 metro (3' - 3")
1 yarda cuadrada o 0.8 m^2	1 metro cuadrado

LO METRICO EN LA COCINA

Cambiar a lo métrico en la cocina será un proceso gradual. Muchos de los enlatados y empacados, ya se encuentran en los estantes del mercado marcados con los dos sistemas, con las unidades del sistema métrico y con las del usual. La lista de abajo muestra los nombres métricos que se usarán en vez de las antiguas unidades.



	Unidades Antiguas	Unidades Métricas	Símbolos
¿Cuanto contiene?	galón, cuarto, pinta onza líquida	litro mililitro	l or ℓ ml
¿Cuánto pesa?	libra, onza	kilogramo gramo	kg g
¿Cuánto mide?	pie, pulgada, fracción de pulgada	centímetro milímetro	cm mm
¿Qué temperatura?	grados Fahrenheit	grados Celsio	°C
Valores de Energía (Con la finalidad de dieta)	Caloría (Kilocaloría)	kilojulio	kJ

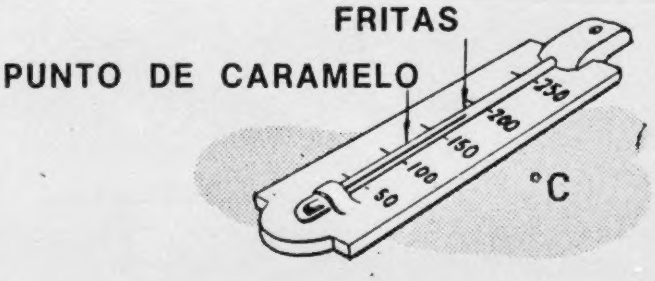
1. Muchos de los tamaños en lo métrico son similares a las unidades familiares antiguas.

PESO (MASA)

Unidades Antiguas	Unidades Métricas
1 onza iguala a 28.35 g	30 gramos para reemplazar a 1 onza
3-1/2 onzas igualan a 99 g	100 gramos para reemplazar a 3.5 onzas
1 libra iguala a 454 g	500 gramos para reemplazar a 1 libra
2 libras igualan a 908 g	1 kilogramo para reemplazar a 2 libras
2.2 libras igualan a 1 kg	

2. Balanzas métricas para la cocina se consiguen con graduaciones de 5 a 50 gramos.

3. Las temperaturas para cocinar son fáciles. La temperatura en grados Celsio en esta clasificación de temperatura es cerca de la mitad de la Fahrenheit.



Termostato Fijo en °F	Termostasto Fijo en °C
275	140
300	150
325	160
350	180
375	190
400	200
425	220
450	225

VOLUMEN

Unidades antiguas	Unidades Métricas
1 cuarto o 946 ml	1 litro o 1000 ml
1 pinta de 473 ml	1/2 litro o 500 ml
1 taza o 237 ml	1 taza métrica o 250 ml
1 cuchara grande o 14.8 ml	1 cuchara grande métrica o 15 ml
1 cucharita o 4.9 ml	1 cucharita métrica o 5 ml

4. Comprar es fácil si usted recuerda que un kilogramo tiene cerca de **2.2 libras** y un litro tiene un poquito más que un cuarto. La tabla de abajo le dará a usted una guía general para las compras.

VOLUMEN

Receta	Compre Por Lo Menos
1 oz líquidas	30 ml
2 oz líquidas	60 ml
1/4 de pinta	125 ml
1/2 de pinta	250 ml
1 pinta	500 ml

PESO

Receta	Compre Aprox
1 oz	30 g
2 oz	60 g
4 oz	125 g
8 oz	250 g
1 lb (16 oz)	500 g

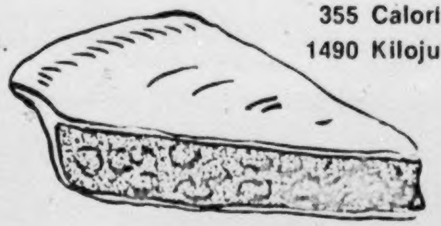
5. El kilojulio reemplazará a la Caloría. Cerce de 4.2 kilojulios igualan a 1 Caloría. Una dieta de 2 000 sería una dieta de 8400 kilojulios.

6. Buenas recetas deberían estar en tamaños métricos completos.

Por ejemplo: 1 taza métrica o 250 ml

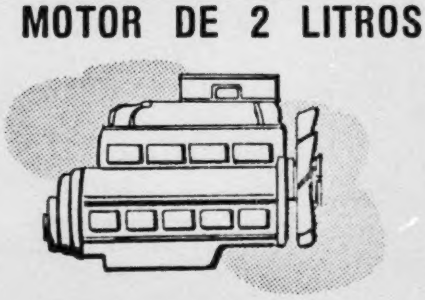
1 cuchara grande métrica o 15 ml

1 cucharita métrica o 5 ml



LO METRICO PARA SU CARRO

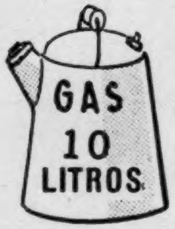
1. El tamaño de un motor (desplazamiento) se da en litros o centímetros cúbicos en vez de pulgadas cúbicas. Esto es el volumen de un cilindro multiplicado por el número de cilindros. Por ejemplo, un motor de 2.3 litros es también un motor de 2300 centímetros cúbicos (el viejo e incorrecto término 2300 cc se usa a menudo).



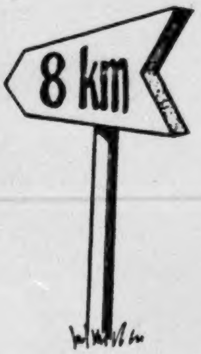
2. El poder del motor se da en kilovatios (kW). Un caballo de fuerza iguala a cerca de 0.75 kilovatios. Un motor de 150 kW reemplaza a un tamaño de 200 caballos de fuerza.

3. El consumo de gas es en litros por 100 kilómetros (1/100 km).

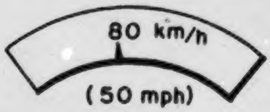
4. Todos los productos líquidos, gas, aceite y anticogelante, sevenderán por litros. El litro es cerca del 6 por ciento más grande que un cuarto, así que hay cerce de 3.75 litros en un galón. Un tanque de 10 galones sería un tanque de 38 litros. Un tanque de 20 galones sería un tanque de 75 litros.



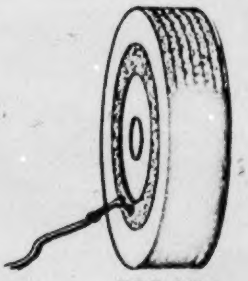
5. El kilómetro se usa para todas las distancias por carro. Tiene cerca de 5/8 de milla o hay 8 kilómetros por cada 5 millas.



6. Las velocidades se dan en kilómetros por hora. La velocidad de 80 kilómetros por hora es igual a la velocidad de 50 millas por hora.



7. Todas las presiones se dan en kilopascales (kPa). Un psi (libras por pulgada cuadrada) es igual a cerca de 7 kilopascales. Por eso, la presión de una llanta de 30 psi sería igual a cerca de 210 kPa.

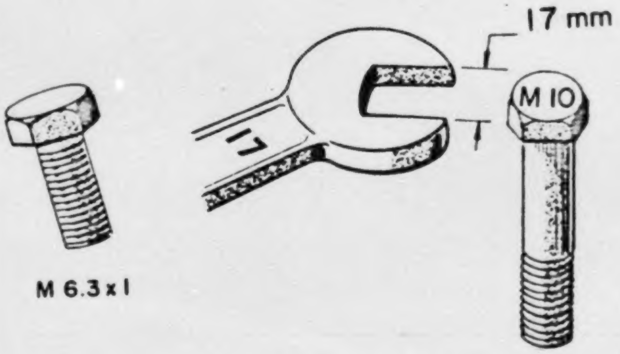


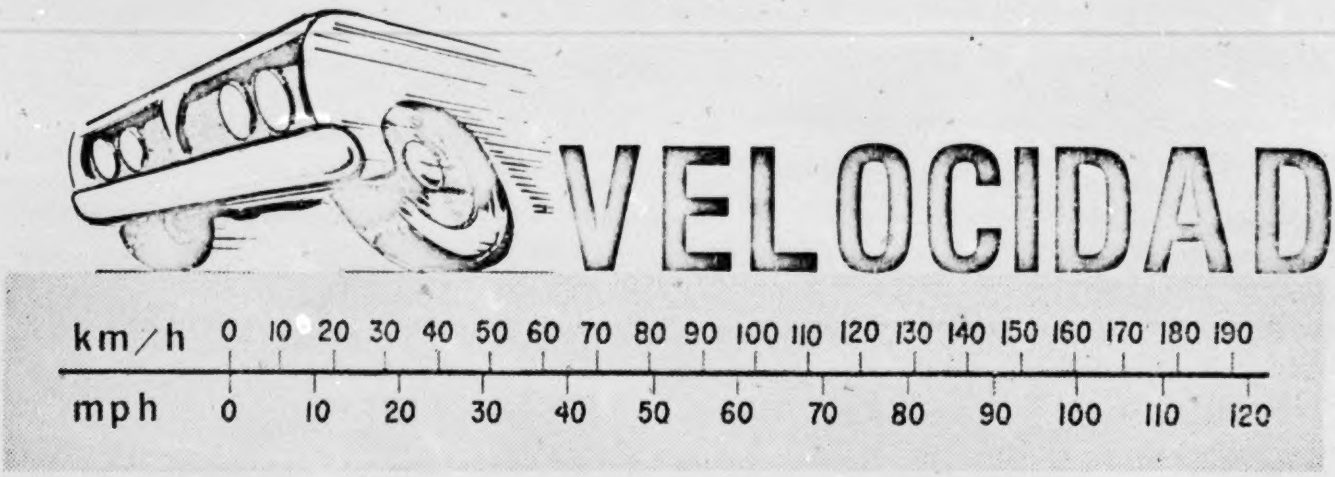
8. Los tornillos sujetadores tendrán roscas métricas ISO. Por ejemplo, M6.3 x 1 tiene 6.3 milímetros de diámetro (casi exacta mente un cuarto de pulgada) y tiene un paso de 1 milímetro (distancia de una rosca a la otra).

9. Un juego de llaves de tuerca, métricas se necesitarán para trabajo de reparación.

ALGUNAS ROSCAS METRICAS COMUNES

ISO Métrico	Roscas De Pulgada Son Similares Pero No Intercambiables
M5x0.8	10-24 UNC
M6.3x1	1/4-20 UNC
M10x1.5	3/8-16 UNC
M12x1.75	1/2-13 UNC
M24x3	1-8 UNC



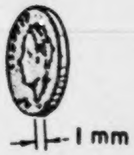


PIENSE METRICAMENTE

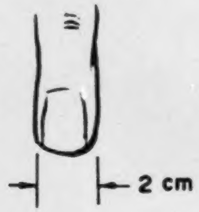
La mejor forma de aprender medidas métricas es "pensar métricamente".

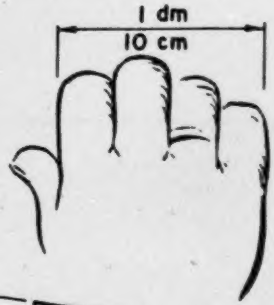
Recuerde estos puntos de referencia comunes:

El grosor de una moneda de diez es 1 milímetro

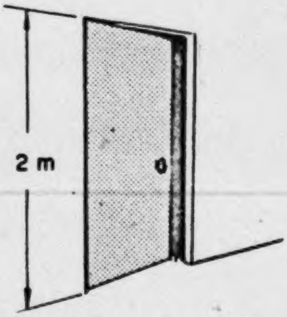


El ancho de sun dedo índice tiene cerca de 2 centímetros.



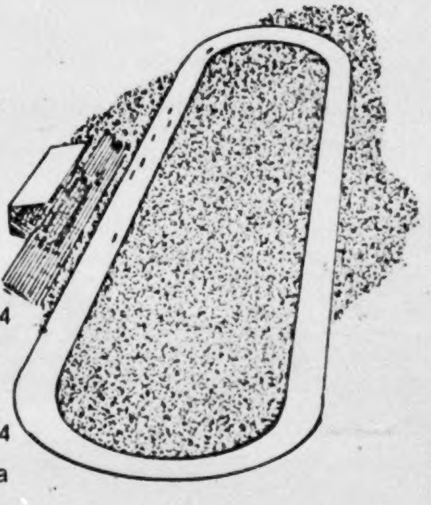


La distancia a través de su puño cerrado tiene cerca de 1 decímetro (10 centímetros).



La altura del vano de una puerta tiene cerca de 2 metros.

La famosa carrera de carros de Indianapolis será de 800 kilometros.



Si usted mismo insiste en pensar en unidades usuales, entonces:

Usted recordará siempre la buena y antigua pulgada como los 25.4 milímetros raros y la precisa onza como los 28.35 curiosos gramos.
PERO -- Si usted "piensa métricamente"
Entonces los nuevos, buenos 25 milímetros llegan a convertirse en .984 pulgades extrañas y el bueno y nuevo gramo llega a convertirse en la peculiar onza de 0.035.

LA RELACION APROXIMADA ENTRE EL SI METRICO Y EL USUAL (INGLES) (DENTRO DEL 10%)

metro = yarda 3 pies

kilómetro (km) = 5/8 de milla

litro = cuarto

kilogramo (kg) = 2 libras

1 mm = 0.040 de pulgada (1/25 o la mitad del camino entre 1/16" y 1/32)

30 cm = 1 pie

10 mm = 0.4 de pulgada = 3/8 pulgada

25 mm = 1 pulgada

---

grados Celsio		Fahrenheit
0 °C	congelación	32 °F
21 °C	habitación	70 °F
37 °C	cuerpo humano	98.6 °F
100 °C	ebullición	212 °F

SISTEMA USUAL	SISTEMA METRICO
LONGITUD	
1 milla = 1760 yardas 1 yarda = 3 pies 1 pie = 12 pulgadas	1 kilómetro = 1000 metros 1 metro = 100 centímetros 1 centímetro = 10 milímetros 1 milímetro = 1000 micrometros
SUPERFICIE	
1 milla cuadrada = 640 acres 1 acre = 43 560 pies cuadrados 1 yarda cuadrada = 9 pies cuadrados 1 pie cuadrado = 144 pulgadas cuadradas	1 kilómetro cuadrado = 100 hectareas 1 metro cuadrado = 100 decímetros cuadrados 1 decímetro cuadrado = 100 centímetros cuadrados
VOLUMEN	
1 yarda cúbica = 27 pies cúbicos 1 pie cúbico = 1728 pulgadas cúbicas	1 metro cúbico = 1000 decímetros cúbicos 1 decímetro cúbico = 1000 centímetros cúbicos 1 centímetro cúbico = 1000 milímetros cúbicos

FACTORES DE CONVERSION

1 milla	1.6093 km	1 milla cuadrada	2.5900 km^2	1 yarda cúbica	0.8361 m^2
1 yarda	0.9144 m	1 acre	0.4047 ha	1 pie cúbico	28.32 dm^3
1 pie	0.3048 m	1 yarda cuadrada	0.8361 m^2	1 pulgada cúbica	16.39 cm^3
1 pulgada	2.54 cm	1 pie cuadrado	9.290 dm^2		
1 pulgada	25.4 mm	1 pulgada cuadrada	6.4516 cm^2		

COMPARACION DE LAS UNIDADES DE MEDIDA MAS COMUNES

Conversiones aproximadas del Sistema Usual al métrico y vice versa.

	Cuando usted sabe:	Usted descubre que:	Si usted multiplica por:
LONGITUD	pulgadas	milímetros	25.4*
	pies	centímetros	30.48*
	yardas	metros	0.9
	millas	kilómetros	1.6
	milímetros	pulgadas	0.04
	centímetros	pulgadas	0.4
	metros	yardas	1.1
	kilómetros	millas	0.6
AREA	pulgadas cuadradas	centímetros cuadrados	6.5
	pies cuadrados	metros cuadrados	0.09
	yardas cuadradas	metros cuadrados	0.8
	millas cuadradas	kilómetros cuadrados	2.6
	acres	hectómetros cuadrados (hectareas)	0.4
	centímetros	pulgadas cuadradas	0.16
	metros cuadrados	yardas cuadradas	1.2
	kilómetros cuadrados	millas cuadradas	0.4
	hectómetros cuadrados	acres	2.5
PESO	onzas	gramos	28
	libras	kilogramos	0.45
	toneladas mermadas	megagramos (toneladas métricas)	0.9
	gramos	onzas	0.035
	kilogramos	libras	2.2
	megagramos (toneladas métricas)	toneladas mermadas	1.1
VOLUMEN DE CAPACIDAD	onzas	mililitros	30
	pintas	litros	0.47
	cuartos	litros	0.95
	galones	litros	3.8
	mililitros	onzas	0.034
	litros	pintas	2.1
	litros	cuartos	1.06
	litros	galones	0.26
TEMPERATURA	grados Fahrenheit	grados Celsio	5/9 (después de restar 32)
	grados Celsio	grados Fahrenheit	9/5 (entonces añada 32)

*Conversiones exactas

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SISTEMA USUAL	SISTEMA METRICO
PESOS	
1 tonelada = 2000 libras	1 tonelada métrica = 1000 kilogramos
1 libra = 16 onzas	1 kilogramo = 1000 gramos
	1 gramo = 1000 miligramos
MEDIDAS DE CAPACIDAD	
1 galón = 4 cuartos = 231 pulgadas cúbicas	1 kilolitro = 1000 litros
1 cuarto = 2 pintas	1 litro = 1000 mililitros
1 pinta = 16 onzas líquidas	1 litro = 1 decímetro cúbico (dm^3) = 1000 centímetros cúbicos (cm^3)

CONVERSION DE FACTORES

1 tonelada	0.907 de tonelada métrica	1 galón	3.785 litros
1 libra	0.4536 kg	1 cuarto	0.946 de litro
1 onza	28.35 g	1 pinta	0.473 de litro

1 onza líquida	29.57 cm^3
1 onza líquida	0.02957 litro